Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

DECEMBER 1960

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TECHNOLOGY DEPARTMENT

Elbolift at J & L stacks coils in the warehouse, loads boxcars and flat-bed trucks

ELBOLIFT...Littlest BIG truck in the steel industry

AUTOMATIC's Elbolift measures only 80″ high, yet can stack coils weighing up to 25,000 lbs. as high as 120″. Because the truck is narrower than the width of a palletized coil, the truck can stack coils close together, fully utilizing all available storage space.

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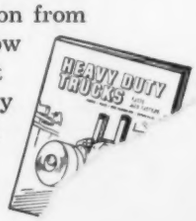

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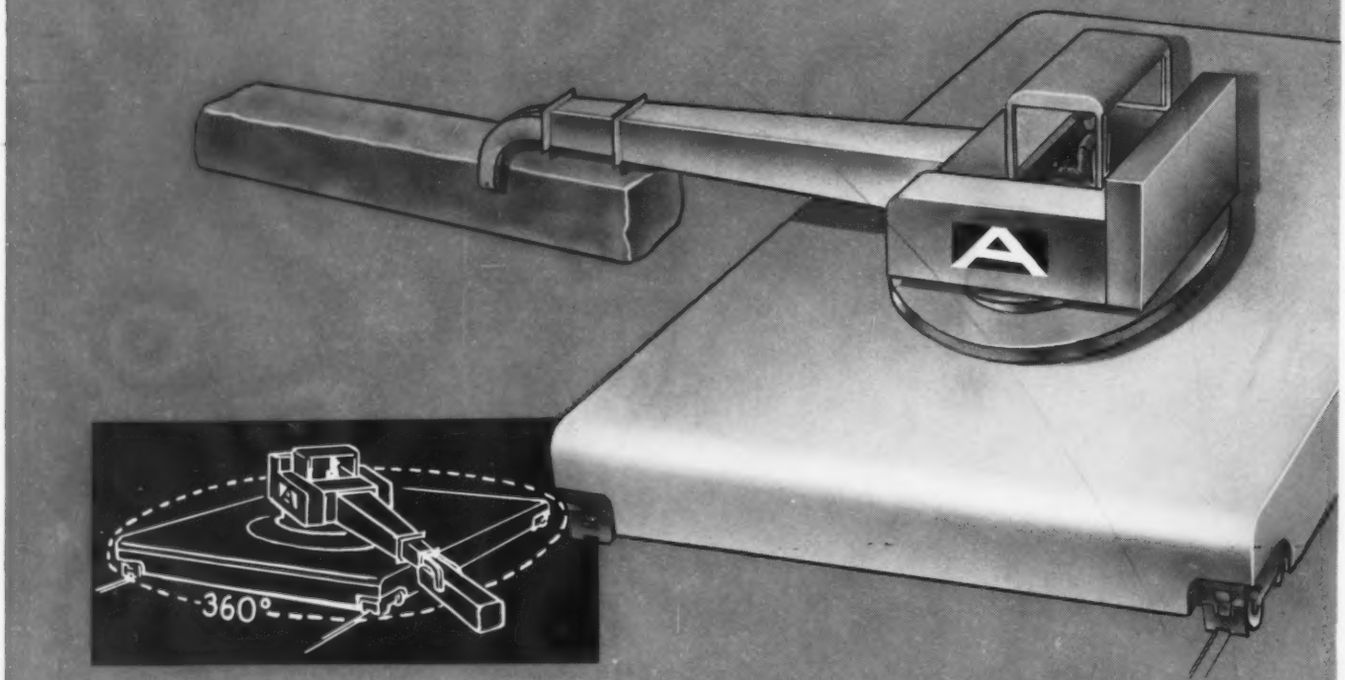

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This is another major unit in the continuing expansion program of Inland Steel Company of Chicago. The line normalizes cold rolled mild steel strip, 16 to 24 ga., 24 to 60″ wide, at furnace speed of 50 to 125 f. p. m. 60,000 lb. coils are fed into the line and 40,000 lb. coils are handled at the delivery end. Shearing facilities included in the line are suitable for sheets from 36″ to 192″.

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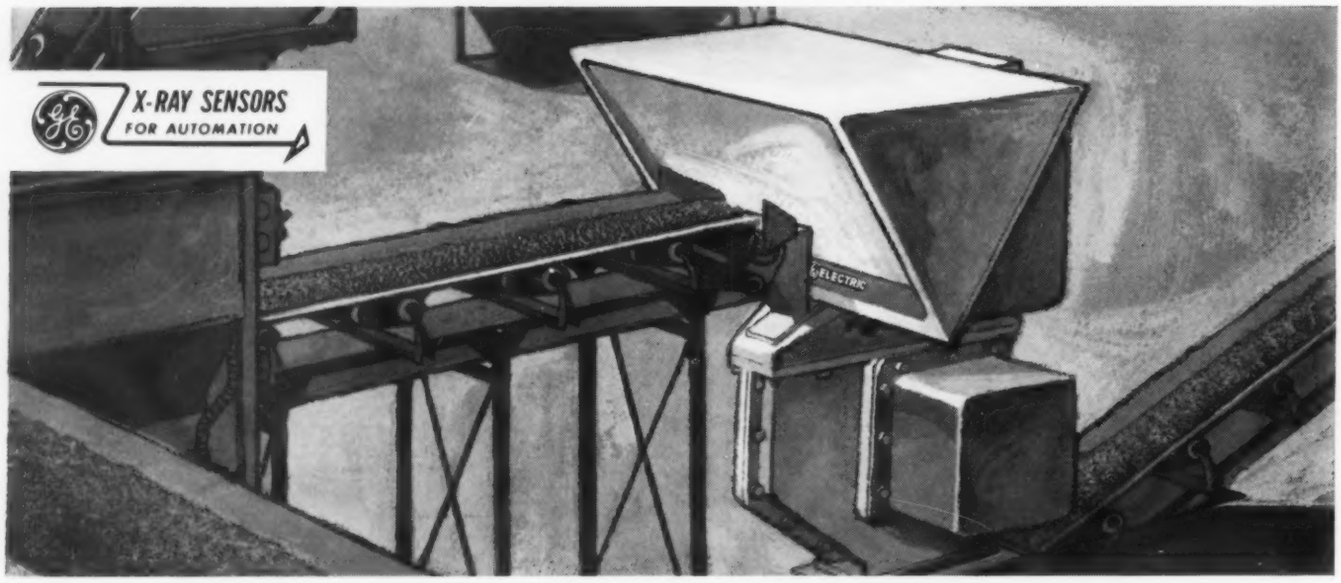

onto the line!

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Iron and Steel ENGINEER

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Published Monthly by

ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING PITTSBURGH 22, PENNSYLVANIA

Statements and opinions given in articles and papers appearing in "Iron and Steel Engineer" are the expressions of contributors, for which the Association of Iron and Steel Engineers assumes no responsibility.

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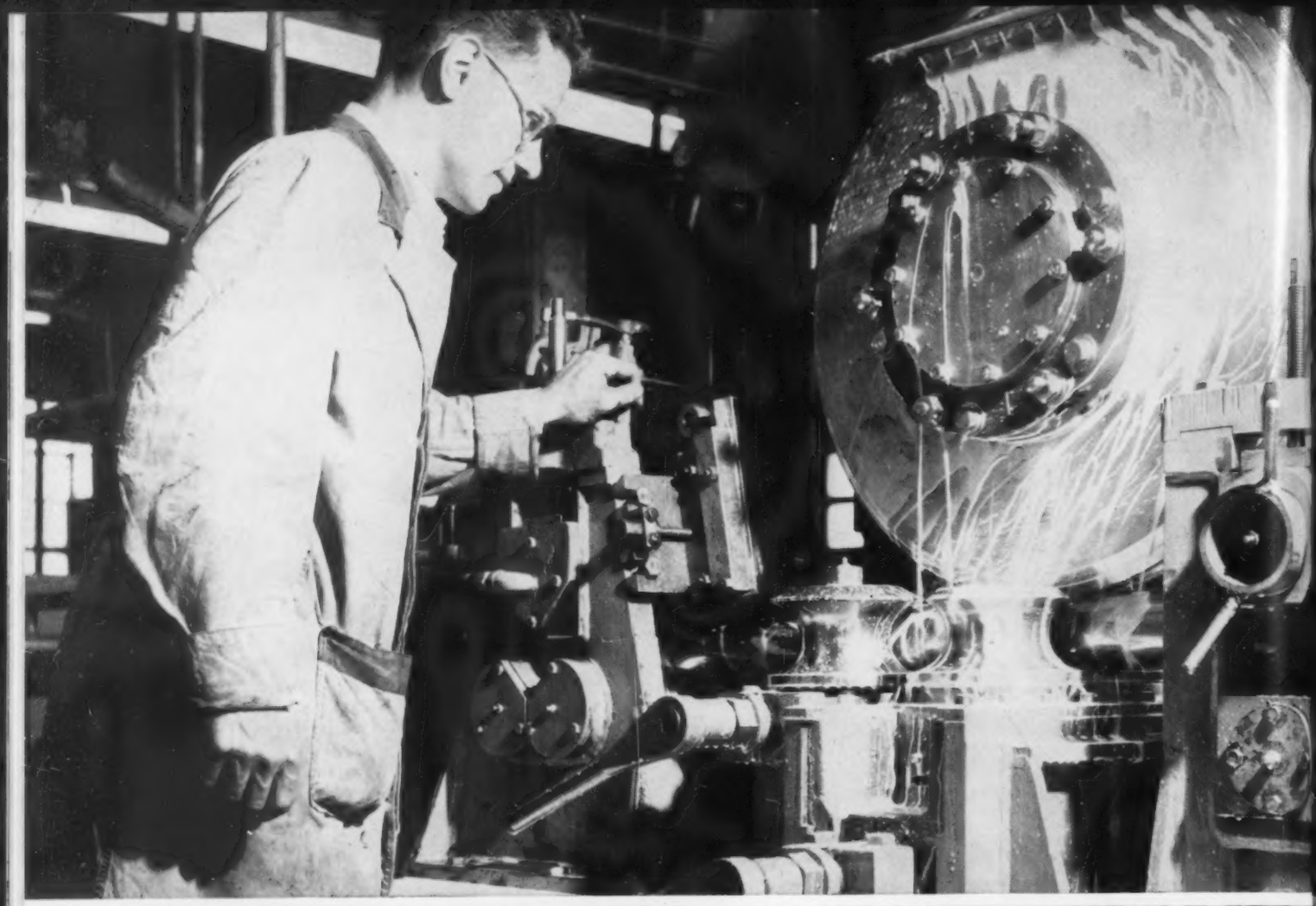
Indexed by Engineering Index and by Industrial Arts Index.

Single Copy Foreign Prepaid $2.00 (U. S. funds) Single Copy $1.50
Subscription price in U. S. and Canada (U. S. funds) ..... $ 7.50 per year
Subscription price in foreign countries (U. S. funds) ..... $10.00 per year

IRON AND STEEL ENGINEER: published monthly by Association of Iron and Steel Engineers at 20th and Northampton Sts., Easton, Pa. Editorial and advertising offices, 1010 Empire Bldg., Pittsburgh 22, Pa. Second-class mail privileges authorized at Easton, Pa. This publication is authorized to be mailed at the special rates of postage prescribed by Section 132.122.



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A CASE IN POINT

Why users prefer McKay Custom Engineered Tube and Pipe Mills

Each McKay tube or pipe mill is designed to provide you with maximum production output at minimum production cost, high quality product, and trouble-free operation. Care is taken to design each component in a tube mill to attain these ends, using the best designs McKay engineers have to offer and the cream of the available ideas of others.

For example, in addition to our own McKay* welding system, McKay offers the amazing new Thermatool® tube welding process for welding both ferrous and non-ferrous tubing and pipe of any diameter. We feel that you deserve the best, since you've learned to expect the best from McKay Machine.

If it's custom engineered by McKay Machine, you can be sure it's designed to exactly fit your specifications, present and future. Before you invest in another tube mill, let us put you in touch with the McKay user nearest you. For if you take the time to compare, you'll find you profit most with a customer engineered tube mill by *The McKay Machine Company, Youngstown 1, Ohio.* *T.M.

®"*Thermatool*" *is a registered trademark of the New Rochelle Thermatool Corporation, New Rochelle, New York, and is used with their permission.*

TOP PHOTO: A 150 KVA McKay Electric Resistance Welding Unit, part of a McKay series 500 Tube Mill at the Canadian Acme Screw & Gear Co., Ltd., Toronto, Canada.

BOTTOM PHOTO: A 450 Kc Thermatool® Welding Unit, installed in a McKay series 400 Tube Mill in the Delair, New Jersey, plant of The Wheatland Tube Co.

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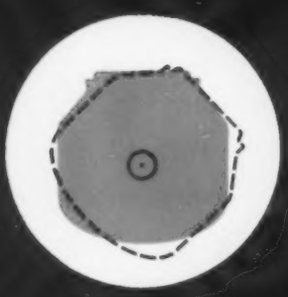
McKAY MACHINE

FOR PROGRESS IN METAL PROCESSING

in oxygen converters . . .



Top: 110-ton capacity furnace (L-D) with PECor-engineered smoke hood and post crane, at McLouth Steel Corporation.

Center: World's largest oxygen furnace (L-D) during assembly, for Jones & Laughlin's Cleveland Works.

Bottom: All PECor drives are soundly made for assured trouble-free service.

YOU GET FAR MORE THAN THE VESSEL FROM PECOR

QUALITY in design and manufacture, reflecting unique experience and constant contact with operating L-D installations. Precision engineered auxiliaries!

RELIABILITY, equipment that "stays on the line" making steel.

SERVICE, including *immediate response* to field requirements, with service as close as your telephone.

May we consult with you in the planning stage?

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Sales Representatives: Wooldridge Company, Burlingame, Calif.
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BUILDER OF AMERICA'S FIRST 15 OXYGEN CONVERTERS

Why is this steel coil half air?

To provide an air-space between each lamination of the coil! This is the key to a revolutionary new method of controlling the composition of steel, known as the Open Coil Process of Gas Alloying. By "opening" the coil and exposing the entire surface to active gases, many exciting things happen to the composition of steel. To name a few: Low grade Bessemer and open hearth steels can be converted to premium products, rimmed steel can be upgraded by decarburization, renitrogenizing and denitrogenizing practices are greatly simplified. The potential is limitless! Mill executives are calling the Open Coil Process "the greatest advance in steel processing in our generation". For complete data call or write . . .

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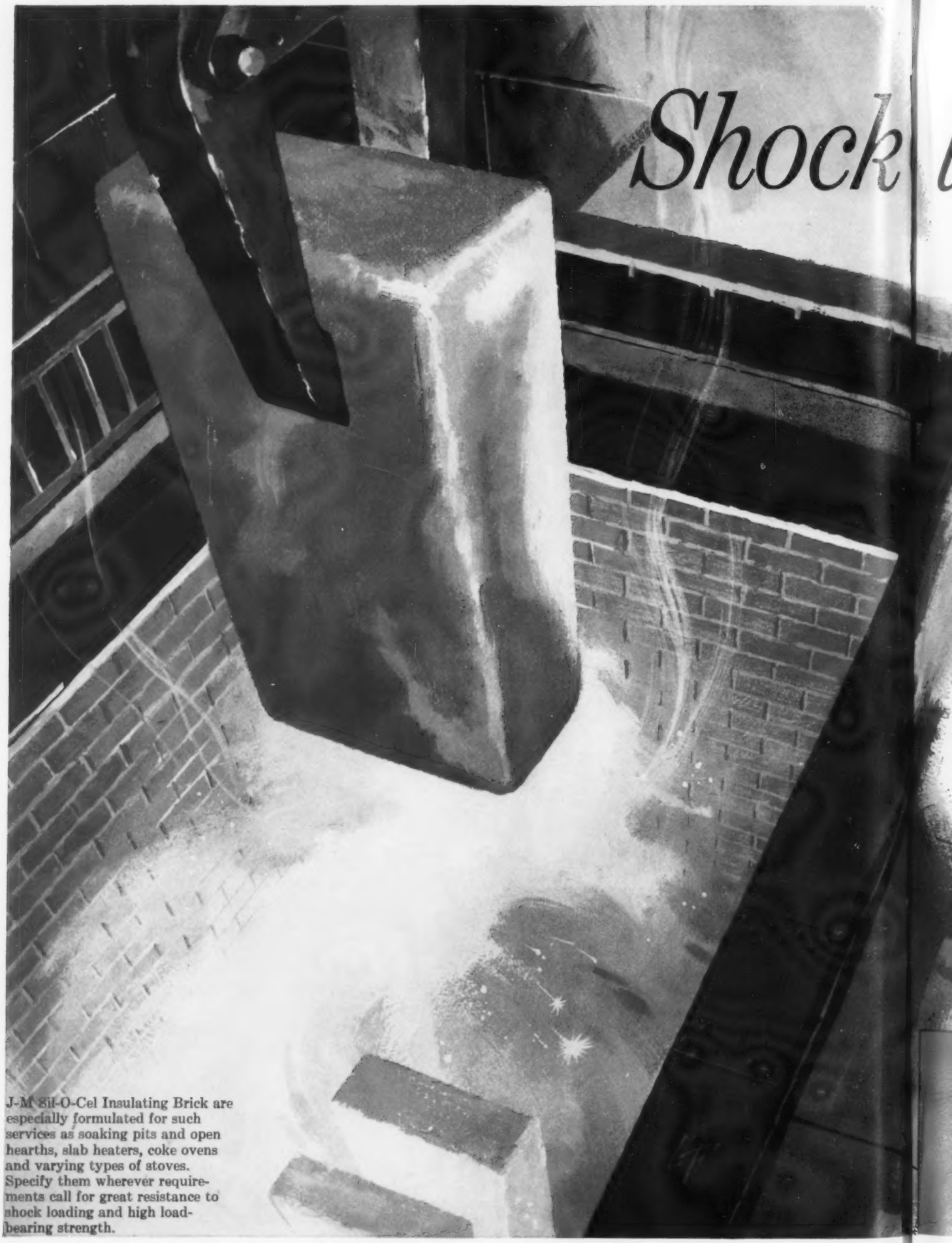
MAKE THE BEST METALS BETTER

* ORIGINATORS AND LEADING PRODUCERS OF OPEN COIL AND SINGLE STACK FURNACES



J-M Sil-O-Cel Insulating Brick are especially formulated for such services as soaking pits and open hearths, slab heaters, coke ovens and varying types of stoves. Specify them wherever requirements call for great resistance to shock loading and high load-bearing strength.

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call for Johns-Manville Sil-O-Cel Insulating Brick!

Hot blast stove walls, open hearths, soaking pit bottoms—the unexcelled performance of J-M Sil-O-Cel® brick in rugged services like these explains their wide acceptance. Today, they are used as back-up insulation by virtually every major equipment builder.

Made of heat-resistant diatomaceous silica, Sil-O-Cel Insulating Brick are produced in three load-bearing types: Sil-O-Cel *Super* (to 2500F) and Sil-O-Cel *C-22* (to 2000F) for peak performance and long life under extremes of heat, weight and shock. Sil-O-Cel *16L* combines performance and economy for lower temperatures to 1600F.

To bring you the right brick for your needs, Johns-Manville *also* offers six Insulating Fire Brick types. This wide selection of Insulating Fire Brick lets you choose the *one* brick that gives you the most favorable combination of temperature resistance, strength, conductivity, density and cost.

Write today for your copy of IN-115A, 8-page booklet on Johns-Manville Insulating Fire Brick. It gives complete physical and thermal properties of each type, along with sizes and shapes available. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

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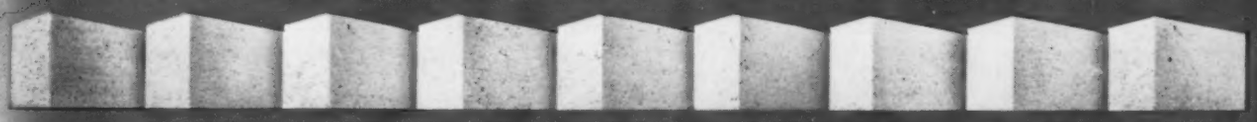
THE INDUSTRY'S MOST COMPLETE LINE OF INSULATING FIRE BRICK



JM-3000	JM-28	JM-26	JM-23	JM-20	JM-1620	Sil-O-Cel® Super	Sil-O-Cel C-22	Sil-O-Cel 16L
service to 3000F	service to 2800F	service to 2600F	service to 2300F	service to 2000F	to 1600F exposed; to 2000F back-up	to 2500F back-up	to 2000F back-up	to 1600F exposed or back-up

15 ton, 40'-0" span Cleveland scarfing gantry operating underneath one of two 40 ton, 90'-0" span overhead traveling Cleveland Cranes in the Slab Conditioning Department. The overhead cranes haul the heavy slabs to and from the scarfing bed area.

SCARFING GANTRY with RAM-TYPE HOIST

OF INTEREST to mill men is the Cleveland single-leg scarfing gantry crane in the Conditioning Department of the Pittsburgh Steel Co., Allenport, Pa. This has a ram-type hoist which eliminates the usual swinging of loads of conventional cable or rope-type hoists. Equipped with two magnets on the ram, the gantry crane handles the heavy slabs in the area it serves and turns them over from one side to the other, enabling the scarfers to clean and prepare them quickly, ready for rolling.

The crane is unusual in that no line shafting or other mechanical connections between the bridge drives at both ends of the crane is employed. Each end truck is individually motor driven. This method of driving the bridge eliminates many bearings and considerable gearing and is an important factor in reducing maintenance to a minimum.

CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
5031 E. 289th ST.
WICKLIFFE,
OHIO

Crops *and* Shorts

△ The nation's steel mills shipped more than 710,000,000 net tons of finished steel products to domestic markets during the 1950's, according to the American Iron and Steel Institute. The largest share of this record decade's tonnage, 139,000,000 tons, went to warehouses and distributors. The automotive industry took 136,000,000 tons and construction 128,000,000 tons. Other major markets included containers, 63,000,000 tons, and machinery and industrial equipment, 61,000,000 tons.

△ William A. Steele, president of Wheeling Steel Corp., told the New York Society of Security Analysts that steel consumption in 1961 may be slightly under that indicated for 1960. He indicated the possibility of new steelmaking facilities, a new hot strip mill and auxiliary equipment for Wheeling in the next five years.

△ This past election is probably the first one in which ballots are still being counted long after the Thanksgiving turkey leftovers are gone.

△ E. J. Hanley, president of Allegheny Ludlum Steel Corp., sees American industry, American labor and the American people as a whole faced with a brand new economic situation: the industrial resurgence of a major part of the free world, offering both challenge and opportunity different from any known by this generation in business.

△ J. Roy Price, assistant director of the Office of Civil and Defense Mobilization told the Pittsburgh regional meeting of the American Iron and Steel Institute of three responsibilities to be met by business and industrial leaders:

1. To revitalize overseas operations in order to recoup America's share of the world markets and at the same time to secure the respect and friendship of the underdeveloped nations.
2. To strengthen and expand the nation's defense mobilization base.
3. To protect the nation's industrial plant, including its most important resource—manpower—against the effects of nuclear attack.

△ Some statisticians figured out that Americans spend more for government than they spend on all food, clothing, medical care and religious activities combined. Seems it's getting to be an expensive luxury.

△ A study made by Research Institute of America indicates that most businessmen are willing to give up capital gains treatment of depreciable property sales in return for a more adequate depreciation system. Businessmen said investment decisions to increase capital expenditures would be spurred if the government would liberalize depreciation allowances.

△ Along the same line, Canada's 15-year experience with faster tax write-offs clearly shows that liberalization of depreciation allowance will not impair government revenues.

△ One thing worse than being on the wrong side of an argument is to be in the middle of it.

△ Maybe we're not the red-hot salesmen we think we are. A recent editorial in Printers' Ink related the following story, told by a member of a U. S. Trade Mission to Japan:

In Kobe, Japan, the managing director of a large steel mill told the mission that the plant had recently installed some new rolling equipment. Before doing so, he had simultaneously sent inquiries to American, French and West German companies. In eight weeks the American company answered by mail. The French company's letter came in five weeks. But the West German company in three weeks had their board chairman and president in Kobe. Guess who got the order.

The same editorial quotes John G. Forrest, business and finance editor of the New York Times, as follows: "At present, the United States has the lowest percentage of international trade, in relation to gross national product, of any country in the free world."

An incident along the same line involved a safety razor purchased fully 40 years ago. It's a dandy, far better than succeeding models, but the ravages of time and constant use have brought its appearance to the borders of unrespectability. A letter to the company inquiring as to the availability of a duplicate brought no answer other than a form letter enclosing, they said in answer to my request, sample razor blades of a new type just brought out.

Incidentally, the new blades are excellent, but work much better in the old razor than in the new models.

△ The Houghton Line says she didn't want to marry him for his money but there just wasn't any other way to get it.

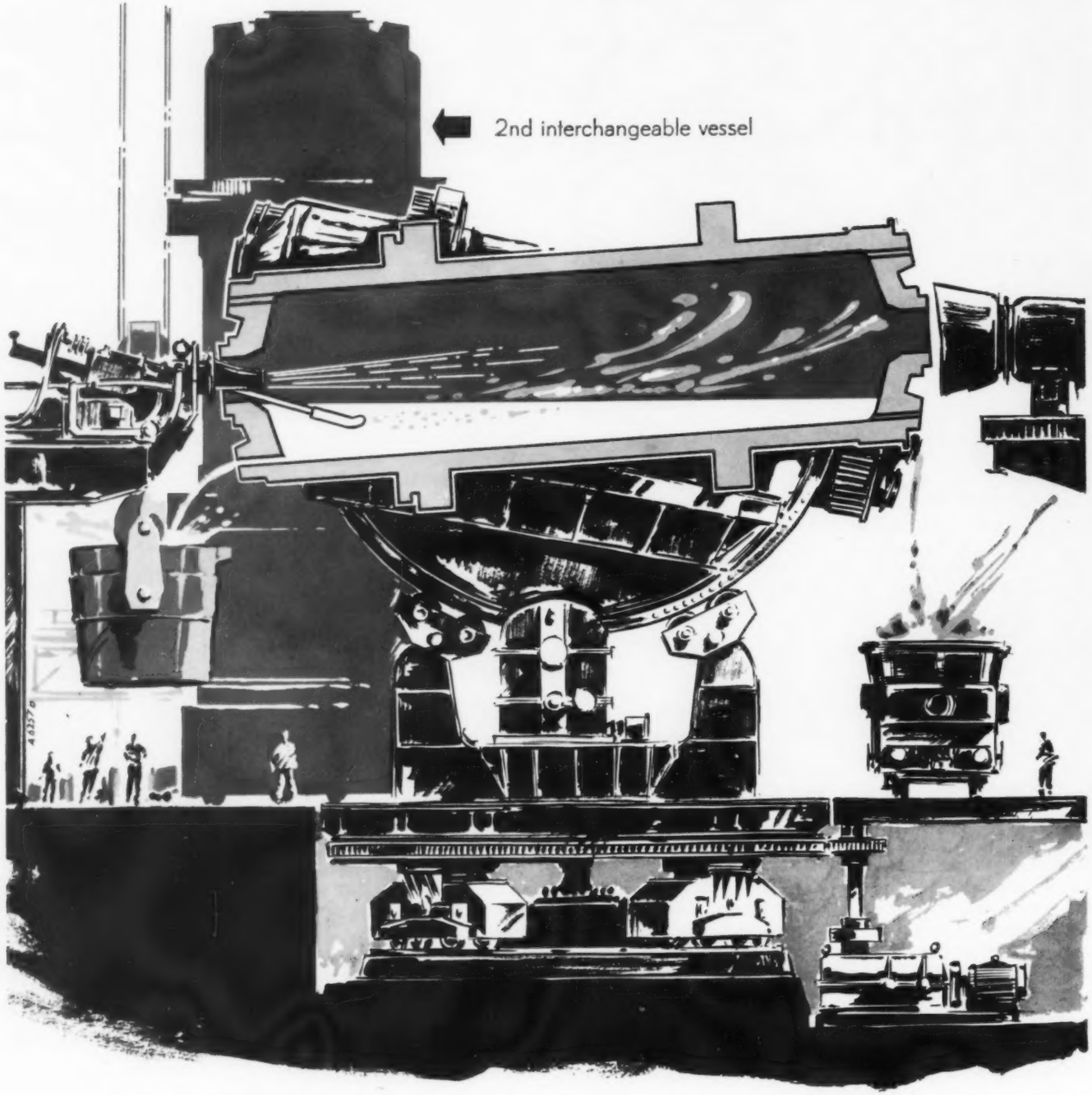
Also: Money may not help you make friends, but it will get you a higher grade of enemies.

△ Forbes magazine reports that the United States is no longer the most inventive nation but actually ranks near the bottom among industrial countries in inventions per capita. The publication says that intellectual climate in the United States is not as conducive to inventiveness as it should be. In spite of $12,000,000,000 spent each year, U. S. industry restricts scientists, promoting conformity and inhibiting creative work. Too often a team approach to research is used instead of encouraging individual initiative.

△ Apropos of the season:

"Let's give one another practical gifts"
She says, as Christmas nears,
And hastens to add that a good mink coat
Will last for years and years.

△ And with that, we'll just say "A real good Christmas and a happy, prosperous New Year."



DEMAG

Cost-conscious Engineering

Among the latest methods of rational steel production is the Rotor Process in which hot metal is refined into steel of open-hearth quality with the help of oxygen. The furnace is mounted on a tilting cradle so that two interchangeable vessels can be employed. Production need thus not be interrupted when relining is necessary. DEMAG has designed and constructed to its own system plants of 75 to 100 ton capacity for European and overseas customers.

DEMAG AKTIENGESELLSCHAFT DUISBURG GERMANY

US-Representatives: American DEMAG Corporation, One Gateway Center, Pittsburgh 22, Pa

Another example of National Roll quality control

"Easy" Esary, left, National sales representative and Larry Weaver, iron foundry supervisor, discuss a double-pour operation at National's Avonmore plant.

Double-pouring gives longer roll life

Double-pouring is a foundry technique in which a special, high hardness iron is poured first and allowed to form the outer roll shell; then a low alloy cast iron is poured, displacing the still-molten special composition iron to form a shock-resistant roll core and more easily machined necks.

Apart from the interesting, precise foundry procedures, double-poured National NN Nickel Iron Rolls have real advantages to roll users—high surface hardness needed for certain applications, plus a tough, resilient core that stands up in hard service.

National Roll's only business is rolls; steel, iron and nodular iron. That's why we have developed a team of metallurgy and production experts that is outstanding for its experience and the service it can render to roll users.

Much of the National story is told in a new brochure that soon will be off the press. Write for a copy. It helps explain why . . .

National's the growing name in rolls

NATIONAL ROLL & FOUNDRY DIVISION

GENERAL STEEL CASTINGS CORPORATION, Avonmore (Westmoreland County), Pa.

General Steel Castings Corporation, General Offices: Granite City, Illinois • Plants: Granite City, Ill., Eddystone, Pa., Avonmore, Pa.

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RCA 110 Electronic

Engineered to withstand the rigors of industrial environment...an ultra high-speed control system ...tailored to your exact needs

The RCA 110, an advanced solid state industrial computer, offers capabilities that range from simple automatic monitoring and recording to complete real-time computer control of complex industrial operations.

From its very concept, the RCA 110 was designed for continuously operating processes, and built for maximum effectiveness under the hardest industrial usage. It is housed in dust-tight heavy steel cabinets and air-cooled by internal heat exchangers to guard against contamination from outside atmosphere. The entire system is programmed so that it will continuously check itself. In the event of main power failure, the RCA 110 calls into action a "safe shutdown" sequence without loss of computer memory or instability to the controlled system. Wired-in priority interrupt helps make the RCA 110 the most efficient industrial computer offered anywhere.

Like all RCA Electronic Data Processing Systems, the "building-block" concept of the RCA 110 permits custom-assembly of the system according to your special requirements, and easy expansion as your needs demand.

For detailed information on the world's most advanced industrial control computer, ask your nearest representative of the Foxboro Company, or write —Industrial Computer Systems Dept., Electronic Data Processing Division, RADIO CORPORATION OF AMERICA, 21 Strathmore Road, Natick, Mass.

The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

6 REASONS WHY THE RCA 110 IS THE WORLD'S MOST EFFICIENT INDU

DESIGNED FOR FAIL-SAFE CONTINUOUS OPERATION even under the most exacting factory conditions. Dust-tight, heavy-duty all-steel enclosures are equipped with industrial heat exchangers for internal cooling to prevent contamination from outside atmosphere. Requires no false flooring or other special site preparations.

UNIQUE PRIORITY INTERRUPT FEATURE enables computer to automatically select the most urgent task from multiple demands. Operates on programmed priority basis, to avoid traffic jams and to handle emergency situations immediately. Result—programs are easier to write, memory space is conserved, and computer free time is automatically assigned to self-checking routines.

MAXIMUM SYSTEM ACCURACY IS SAFEGUARDED with low impedance, single path ground scheme—permits low level signals to be processed by computer, eliminating cross talk interference from main frame currents. Employs solid co per, 150 pound bus bar as integral part of grounding system

HEAVY DUTY SOLID STATE POWER SUPPLY includes separate metering and adjustment of all DC voltages, automati alarming of over-voltage, and circuit breaker protectio against current overload. Motor driven control eliminate start-up shock and prolongs life of all components. Reser capacities in power supply, plus priority interrupt routin safeguard memory information, and safely shut down th computer in event of main power failure. Entire syste sectioned and metered for high-speed, automatic check-ou

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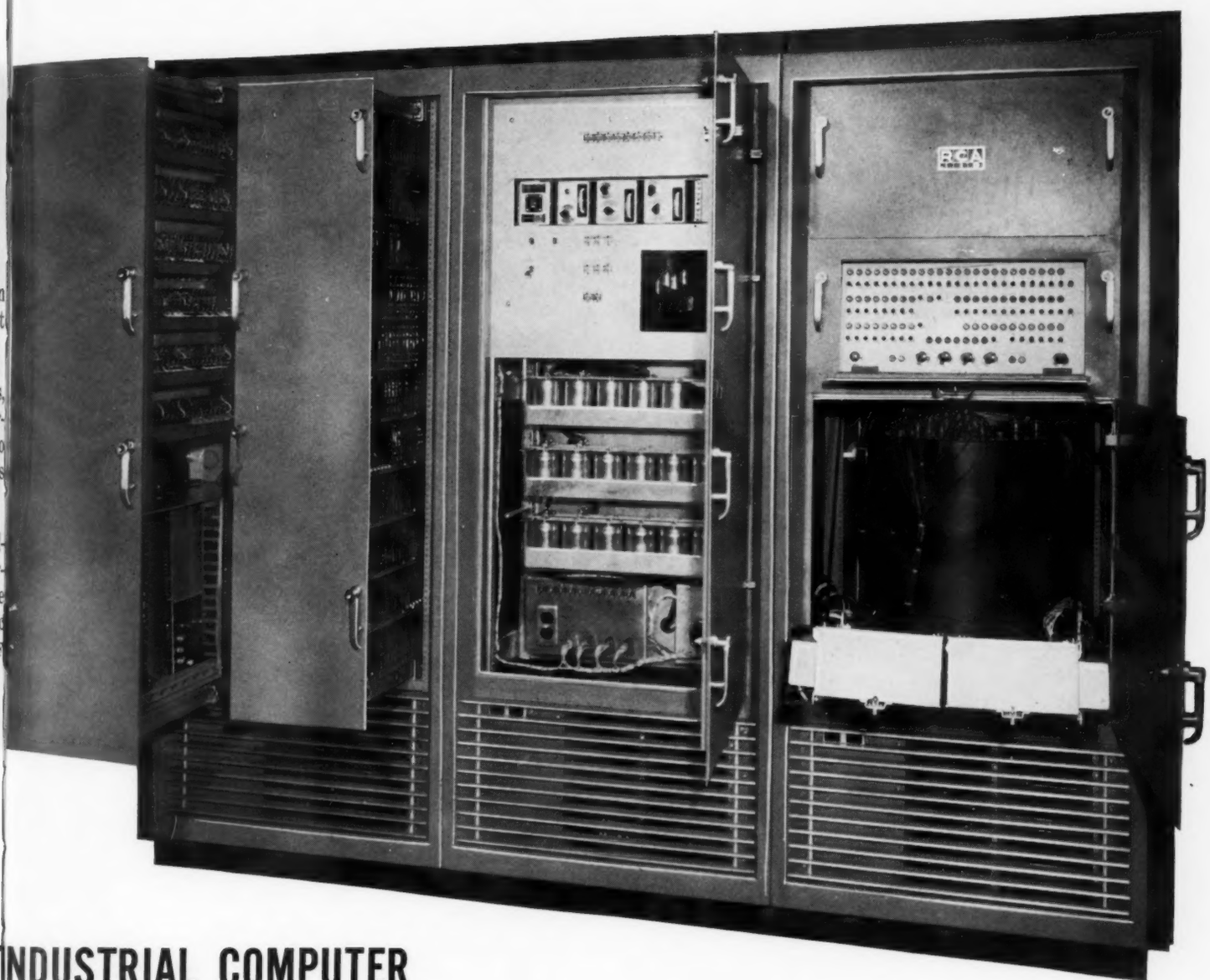

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ASY MAINTENANCE EVEN DURING OPERATION—all circuits accessible from front in extendable drawers and hinged chassis. Industry's most complete maintenance panel permits manual check-out of complete system. Computer continues to operate with all drawers fully extended. Circuits are designed to perform at high temperatures—have built-in marginal testing, and an automatic alarm signals improper operating voltages.

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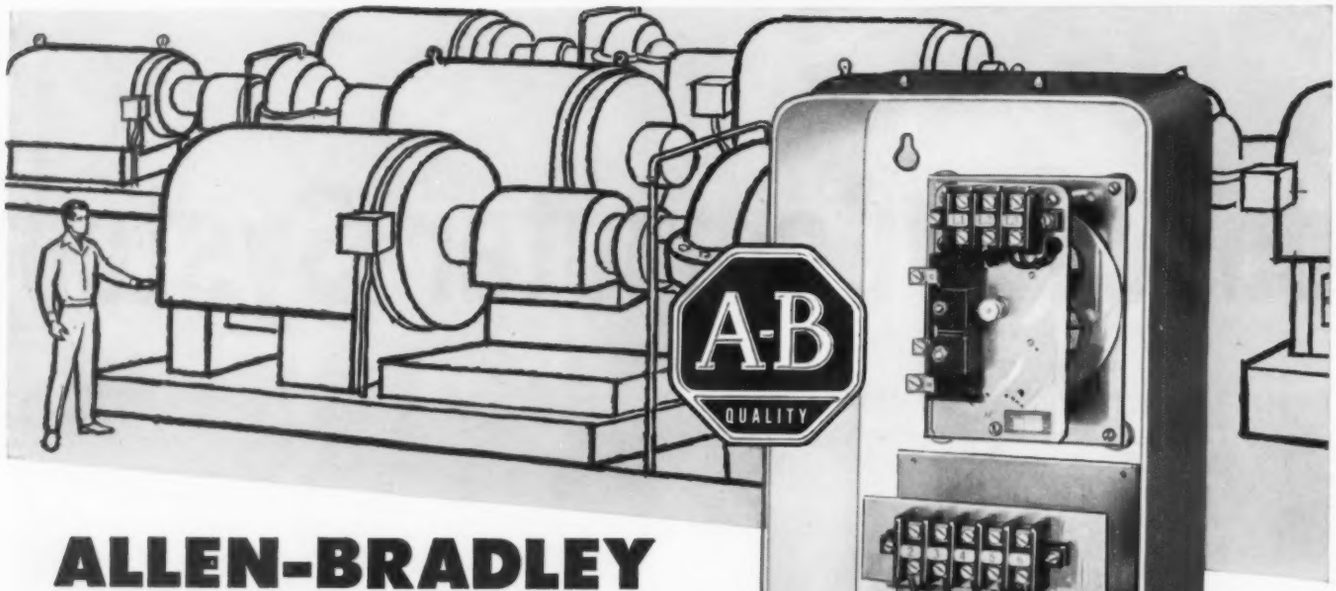
Speed — including access time and staticizing, adds in 56 microseconds, multiplies in 728, divides in 868. *Instructions*—one address (limited two address), 7 indexable address registers, 71 wired-in instructions. *Number System*—fixed point, binary or binary coded decimal. 24 bit word length, word time 28.89 microseconds. *Working Storage*—magnetic core, coincident current, variable in size from 256 to 4096 words, 8 high-speed input-output registers, clock frequency 936 kilocycles. *Bulk Storage* — magnetic drum, 3600 rpm, 4096 to 51,200 words, 8.3 milliseconds average access time, 200 kilocycle transfer rate, up to 12 buffer tracks for input-output. *Size*—82" high, 34" deep, 105" long. *Typical Power Input*—5 kva, 220 volts.



ALLEN-BRADLEY PHASE FAILURE *and* PHASE REVERSAL RELAYS

will provide positive protection for high-horsepower, high-priced motors!

It's sound "economy" to guard your investment in expensive motors and equipment against the extensive damage that can result from a phase failure or phase reversal. Allen-Bradley's Bulletin 812 Style RF relay provides *complete, positive* protection against both of these hazards.

The Bulletin 812 Style F phase failure relay instantly detects *all* open phase conditions on a motor branch circuit and removes the motor from the line—yet is not subject to nuisance dropouts from transient line fluctuations. An unusual feature of this Style F relay is its positive response, regardless of motor load or type of motor branch circuit employed.

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All A-B Bulletin 812 relays are completely "fail safe." It will pay you to investigate this economical insurance against the heavy losses that can—and *frequently* do—result from phase failure and phase reversal. Write today!

Allen-Bradley Co., 1343 S. First St., Milwaukee 4, Wis.
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Bulletin 812 Style RF for Phase Failure and Phase Reversal consists of Style F Phase Failure and Style R Phase Reversal relays in the same enclosure.

Bulletin 812 Style F for Phase Failure

Bulletin 812 Style R for Phase Reversal

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PITTSBURGH, PENNSYLVANIA

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Solvents and a pipeline pig did the job. But for different conditions, D. I. S. uses other techniques to get the same result. For example, when scale blocked a 24-inch, quarter-mile-long waste line, D. I. S. engineers knocked out the deposits with a special D. I. S.-designed jet mole. Though this underground pipeline was buried 10 feet deep, D. I. S. cleaned it completely in only 16 hours!

Nation-wide Dow Industrial Service first analyzes the job to be done, then selects the technique which will do the best job, fastest. D.I.S. cleans all kinds of lines—fresh water, boiler feed-water, gas, waste and other lines—and every kind of process and heat exchange equipment.

In addition, D. I. S. offers complete consulting laboratory service for water treatment and waste processing problems, backed by the technical resources of The Dow Chemical Company. For cleaning *any kind* of equipment, *anywhere* in the U. S., write or call DOW INDUSTRIAL SERVICE, 20575 Center Ridge Road, Cleveland 16, Ohio.

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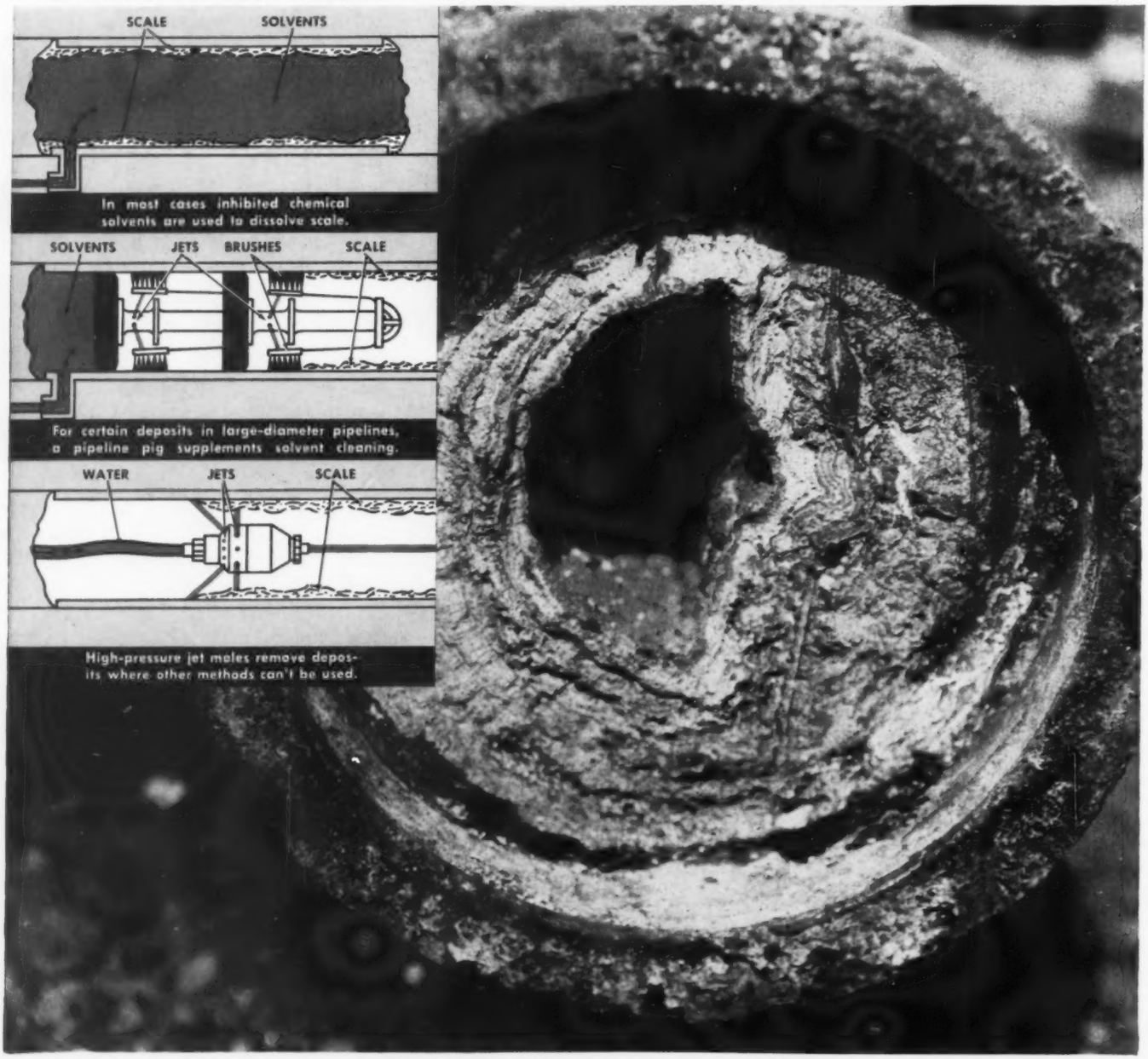
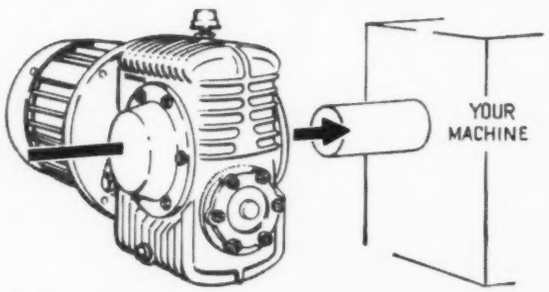
From these three methods, D. I. S. selects the one best suited to your specific pipe-cleaning problem.



CONE-DRIVE GEARMOTORS for "PLUG-IN" POWER



Hollow-Shaft Speed Reducer-Motor forms complete power transmission package . . .

With the compact, right-angle Cone-Drive gearmotor the machine designer can make use of an integral drive package of nearly any required speed and horsepower. Twenty-seven standard output speeds from 7.3 to 525 RPM (with 1750 RPM motor) are available in models from ¼ to 40 horsepower. Gearmotors can be specified with hollow shaft for mounting in any position, ready to "plug-in". You can use this integrated power package to provide a simple, clean installation on your machine . . . no pulleys, belts, sheaves, bed plates, couplings, etc.

Electric motors are standard "D" flange type with slight shaft modification for driving helical primary reduction gears. Secondary reduction stage is a standard Cone-Drive double-enveloping worm gearset with maximum tooth engagement for greater load carrying capacity in smaller space.

Cone-Drive gearmotors are available for all AGMA service ratings. Call your Cone-Drive representative today or write for catalog #58 for complete specifications.

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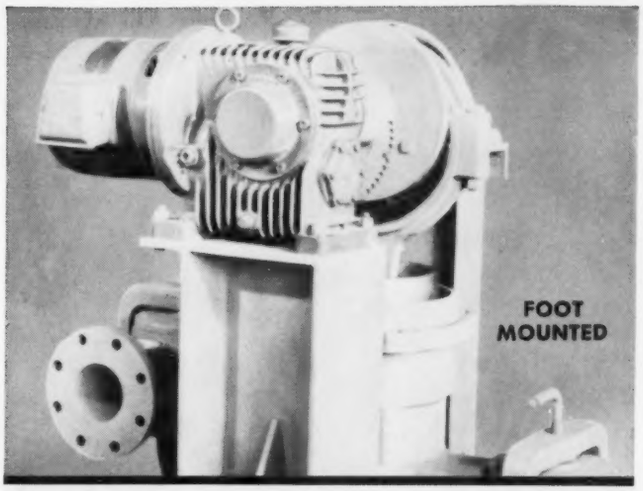
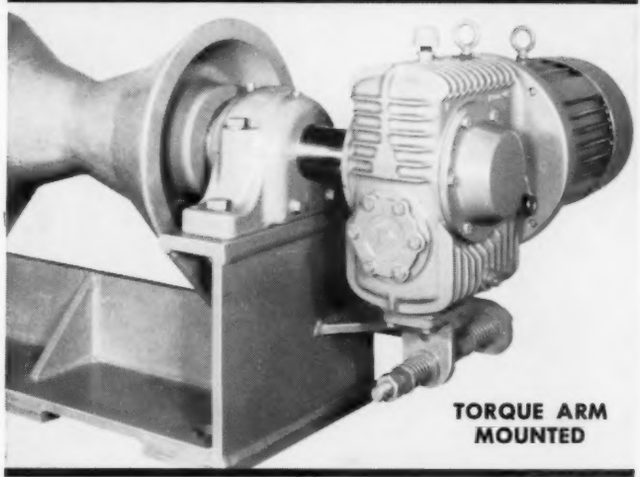
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS





Down go back-up roll costs with

th

USS Quality Forged Sleeves

PICTURED ABOVE is James S. Rennick, a metallurgist with twenty years' experience in the Forgings Division of U. S. Steel. Jim specifies composition, heat treatment, and other processing procedures essential to the production of assemblies as shown in the main picture—a back-up roll that will be used in the cold reduction tin mill at U. S. Steel's Gary, Indiana plant.

This job points up a curious situation: U. S. Steel is one of the country's leading manufacturers of rolls, and also one of the biggest *users* of rolls . . . a double reason to perfect their performance and reduce their cost . . . just as we did here.

We had to replace a worn, cast steel back-up roll. Rather than replace the entire roll, we machined the face of the roll and shrunk on a *forged* steel sleeve. For back-up rolls like this one, 42″ O.D. and larger, this method of sleeving is much less expensive than buying a complete new roll. One arbor can be used for several forged sleeves. A forged sleeve has a hard, wear-resistant surface and is highly resistant to spalling.

Also, the sleeve is purposely produced with a softer bore to develop a desirable stress pattern, and to provide maximum gripping between the arbor and sleeve after assembly.

There is a good possibility that we can help reduce *your* roll costs. Write or call the United States Steel Office nearest you, or United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

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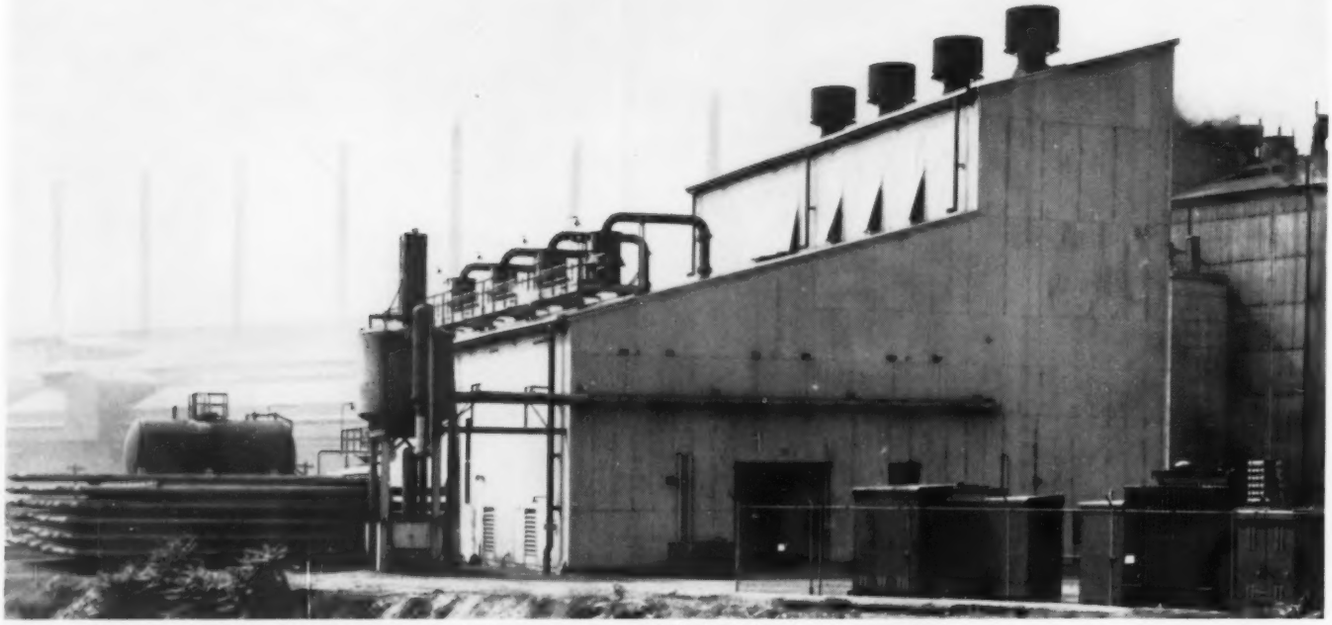
United States Steel Export Company

United States Steel

BRISTOL TELEMETERS RECORD OXYGEN DISPATCHING AT JONES & LAUGHLIN STEEL



Oxygen plant at Jones & Laughlin's Pittsburgh Works. Approximately 69,000,000 cubic feet per month of high purity O_2 are generated here and dispatched by Bristol Metameter* Telemeters to serve the 295-acre works (background).

Miniature strip chart instruments simplify central O_2 dispatching throughout 295-acre Pittsburgh Works

Miniature Bristol Metameter* instruments give the central dispatcher all the information he needs for efficient, economical, oxygen dispatching at the 295-acre Pittsburgh Works Division of Jones & Laughlin Steel.

Among the functions recorded are plant line oxygen pressure, oxygen consumption for billet scarfing, slab mechanical scarfing and blast furnaces, total oxygen consumption for plant, and cubic feet of oxygen storage at standard conditions. The dispatching system has proved entirely satisfactory and capable of meeting emergency conditions.

This is typical of the service Bristol instrument systems are rendering in today's steel plants. They can help you step up production, increase product uniformity, save fuel costs, and release valuable supervisory time for more important duties. They measure, indicate, record, or automatically control a tremendous variety of variables. Just a few of these are: oxygen pressure and flow (current rate and total), oxygen lance position, lance cooling water temperature, fuel flow and pressure (coke-oven gas, natural gas, oil)—as well as complete telemetering and dispatching center instrumentation for both fuel and oxygen pipelines—and electrical quantities: voltage, current, power and resistance.

Why not learn more about Bristol instruments for your steel plant application? Bristol application engineers will be glad to talk over your specific problems. Or, we'll send you data on Bristol instruments for any specific application. Write: The Bristol Company, 123 Bristol Road, Waterbury 20, Connecticut. O.31

*T. M. Reg. U. S. Pat. Off.

Bristol Instrument Panel at Jones & Laughlin Steel's Pittsburgh Works. One section records oxygen flows and pressures, while the remaining two sections record fuel gas flows and pressures. Flow integration is provided on a separate panel not shown.

BRISTOL... for improved production through measurement and control
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MEMO

TO OXYGEN STEEL OPERATORS!

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RECOMMENDATION: Henry Frasch and the manufacturer agreed on "National" Brush Grade SA-45.

RESULTS: Excellent cold weather and tropical performance even where commutator speeds reach 5,000 RPM.

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UNION CARBIDE

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period July 5, 1960 to August 2, 1960.

METHOD OF COATING HOT-DIP GALVANIZED PIPE

△ U. S. 2,944,925, issued July 12, 1960 to Carl R. Lynch and assigned to United States Steel Corp., describes a method of coating hot-dip glavanized pipe, and relates in particular to the treatment of pipe lengths as they emerge from the spelter bath in which they are immersed for coating. The object is to clear out ash adhering to the interior of pipe lengths as they emerge from the coating bath.

As shown in Figures 1 and 2, a galvanizing kettle 10 is provided with means for removing pipe lengths 11 by lifting one end and moving the length longitudinally along an upwardly inclined plane. Such removal means starts the lengths onto a discharge conveyor 12. This conveyor comprises a number of helically grooved rollers 13 journaled in a structural frame 14 and driven in any convenient manner. Rollers 13 move the lengths longitudinally and sidewise in close-order succession and eventually discharge them sidewise into a quench tank 15 containing water or a solution for applying a chemical protective coating to the length.

The uppermost roller designated 13a has a short extension 16 at the discharge end thereof projecting over the edge of tank 15 beyond the ends of the other rollers. Thus, when the lower end of a pipe length is discharged into tank 15 by rollers 13, the upper end of the length will still be supported by extension 16. As the lower end of the length falls into the tank as shown in Figure 2, it slides down a guide plate 17 into the bath. The liquid, preferably a dilute water solution of sodium dichromate, rises through the interior of the length and some of it is vaporized into steam since the pipe lengths are still at a temperature of 600 or 650 F from their immersion in molten spelter in tank 10. The quenching liquid is preferably maintained at a temperature between 150 and 200 F.

While the leading end of the lengths remains supported above the level of the quenching liquid, the rise of the latter through the length and the steam generated as a result, produce a blast or jet through the upper end of the length to the extent of a minor explosion. This affords a wiping action on the interior of the pipe wall sufficient to remove any loosely adherent foreign material without reducing the amount of zinc coating remaining on it. The upper end of the length is then discharged from the end of extension 16 and falls into tank 15 for complete immersion in the bath. After quenching, the pipe lengths are removed from tank 15 in any convenient way.

A vapor shield 18 at the upper end

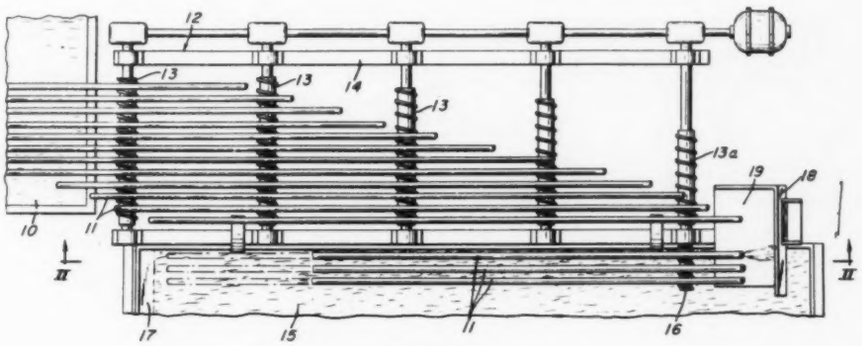
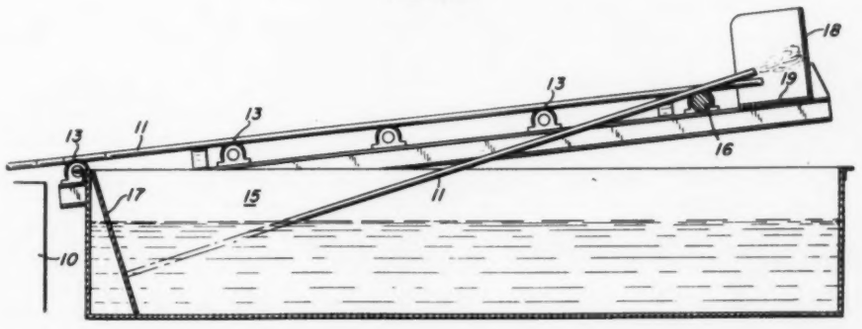


Figure 1

Figure 2



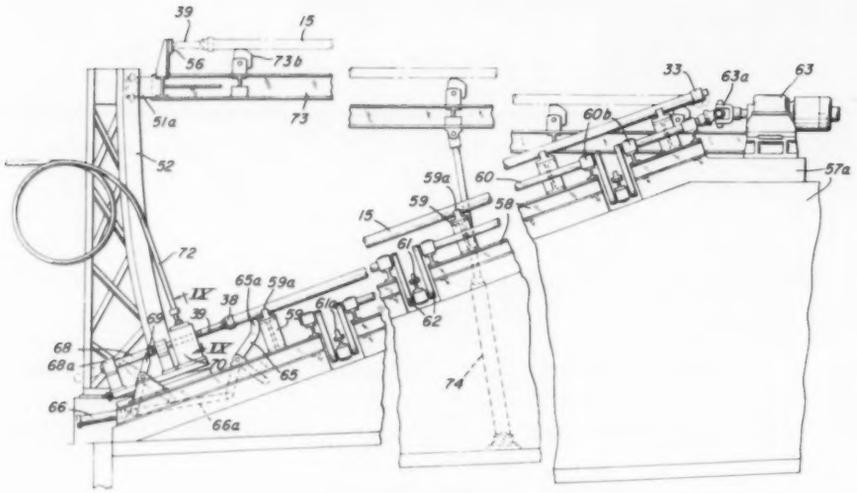


Figure 3

of conveyor 12 partially confines the steam blasts from the ends of the pipe lengths and a bottom plate 19 serves to collect particles blown from the interior of the lengths. Vapor condensing on the shield runs down onto plate 19 and back into tank 15.

HIGH-PRESSURE TESTING OF PIPE

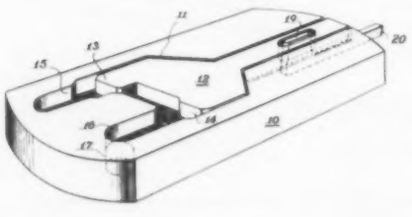
△ U. S. 2,947,165, issued Aug. 2, 1960 to George J. Kirchner and Andrew F. Kritscher, assigned to United States Steel Corp., describes a method and apparatus for high-pressure testing of pipe by hydraulic pressure, which insures that all air will be displaced from the pipe before the full test pressure is applied. This is accomplished by tilting the pipe lengths to an inclined position and introducing water into the lower end. This effects prompt and thorough purging of air through the venting valve at the other end as the liquid level rises through the length. The resulting improved purging of air reduces the amount of high-pressure water required for testing and the time needed to raise the pressure to the maximum value, as well as the possibility of violent explosion in case of failure.

A portion of the apparatus is shown in Figure 3.

HOT METAL VALVE FOR LADLES

△ U. S. 2,943,370, issued July 5, 1960 to Lateef Murarsheed, describes a valve for use in the bottom of a ladle used in handling molten iron and steel.

Figure 4



As shown in Figure 4, the valve body 10 contains a slidable valve element 12 which is provided with a bifurcated front portion with extensions 13 and 14 which register (in closed position) with an inlet area 15 and an outlet area 16. The outlet area 16 communicates with a vertical passageway 17 extending through the bottom of the valve body.

METHOD OF BENEFICIATING IRON ORE

△ U. S. 2,944,884, issued July 12, 1960 to Gaylord H. Halvorson and assigned to United States Steel Corp., describes a method of producing high iron concentrates from low grade ores, such as nonmagnetic taconite.

As shown in Figure 5, iron ore crushed to minus $\frac{3}{8}$ inch is mixed with carbon of a reactive form in mixer 10, and the mixture is charged to a retort 12. The mixture contains at least fifty per cent more carbon than the theoretical quantity needed for complete reduction of the iron in the ore to metallic iron. The ore preferably is a hermatitic taconite which has an iron content of 20 to 50 per cent and a silicious gangue. The carbon preferably is peat char which is low in both volatiles and sulphur. Peat char has advantages in that it is completely noncoking and hence highly reactive.

In the retort the charge is heated to a temperature of 1900 to 2000 F, for 18 to 21 hr. Heat is applied externally of the retort. Gas formed during the reducing reactions is conducted from the retort, and no additional gas is introduced from outside. Since the sulphur content of the charge is low, there is no need to include limestone in the charge. The heating period is sufficiently long that the iron not only is fully reduced, but also carburized. Sufficient carbon is absorbed to produce iron carbide particles that lose their malleability on fast cooling. The iron particles should contain at least about 0.65 per cent carbon. After completion of treatment in the retort 12, the charge is removed and introduced to a water or gas quenching device 13 to provide the desired fast cooling, which produces a martensitic structure within the reduced particles. Next the charge is ground to liberation size and the carburized iron particles and gangue particles are separated magnetically.

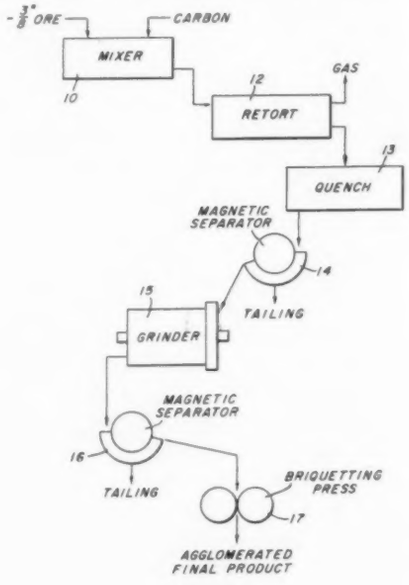


Figure 5

The final concentrate goes to a conventional briquetting press 17 which forms the product into agglomerates of high purity carburized iron suitable for use as scrap in a steelmaking process.

PRODUCTION OF LEAD-CONTAINING STEELS

△ U. S. 2,947,622, issued Aug. 2, 1960 to Michael Tenenbaum, James W. Halley and Frank W. Luerssen, assigned to Inland Steel Co., provides a method of producing steel containing a small amount of lead to increase its machineability. The method of this invention yields leaded steel remarkably free of lead globules and particles.

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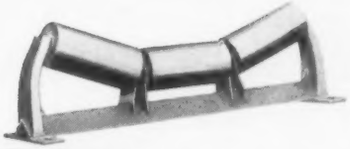

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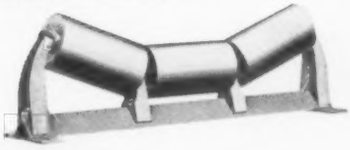

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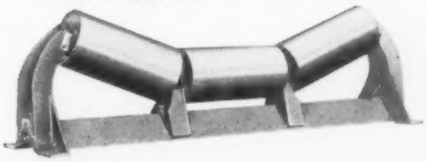

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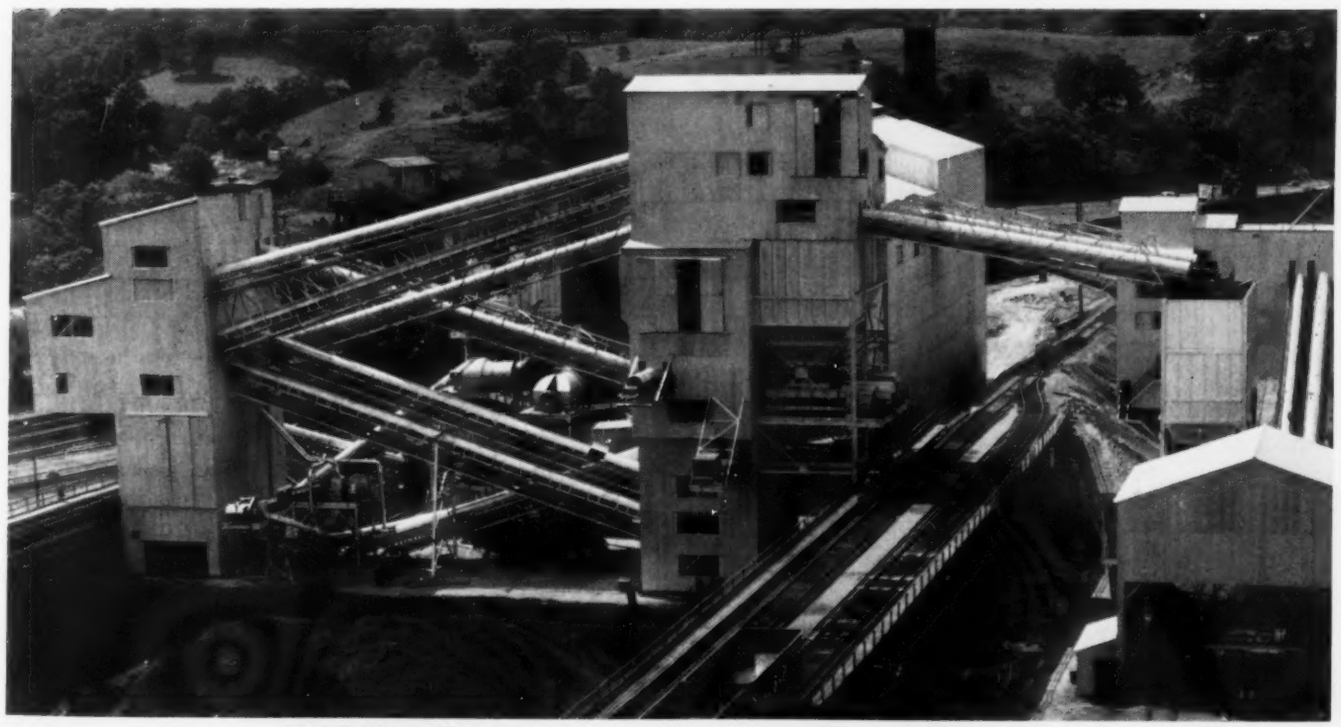

50 BELT CONVEYORS, employing five different sizes of various type idlers, keep raw materials moving steadily through this sintering plant of Armco Steel.

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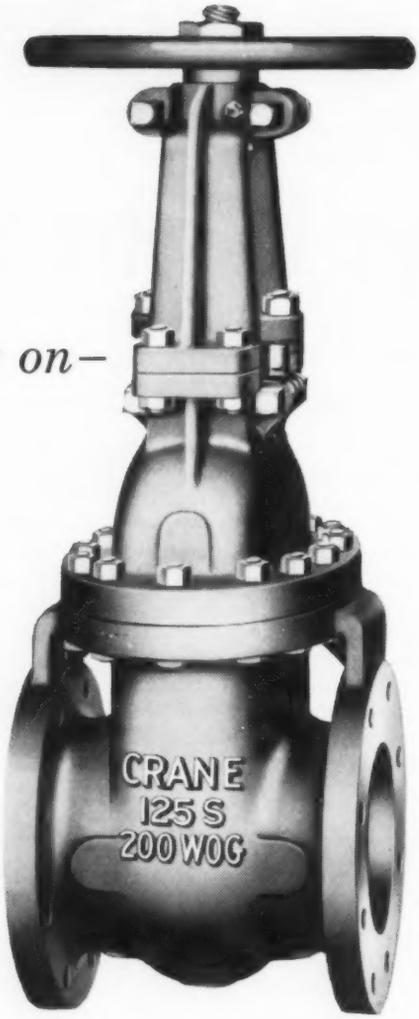

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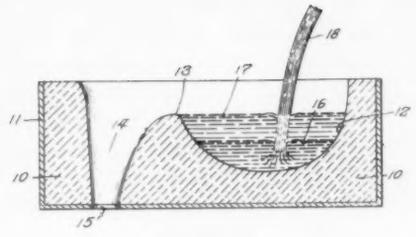


Figure 6

As shown in Figure 6, molten lead 16 is placed in the bowl 12 but to a level appreciably below the lip 13. A stream of molten steel 18 is then caused to flow into the bowl and into the molten lead where the steel stream is dispersed. The molten steel, being the lighter of the two metals, rises to form an upper lead-containing steel layer 17 over the molten lead. As the molten steel stream 18 continues to flow, the lead containing steel layer 17 continues to rise until it spills over lip 13, flows through conduit 14 and out discharge orifice 15. The leaded steel may then be directed to an ingot mold.

PREPARATION OF IRON POWDER CAPABLE OF BEING ROLLED DIRECTLY TO SHEET FORM

△ U. S. 2,947,620, issued Aug. 2, 1960 to Irving P. Whitehouse and William A. Reed, assigned to Republic Steel Corp., provides a process for preparing iron powder capable of being rolled directly to sheet form.

As shown in Figure 7, "dry oxide material" is supplied to a first stage reaction chamber 10, and then is conveyed to a second stage reaction chamber 12, and to a third stage reaction chamber 14 from which they are eventually withdrawn. There is also shown a suitable means for preheating the solid materials as supplied to the reaction chamber 10.

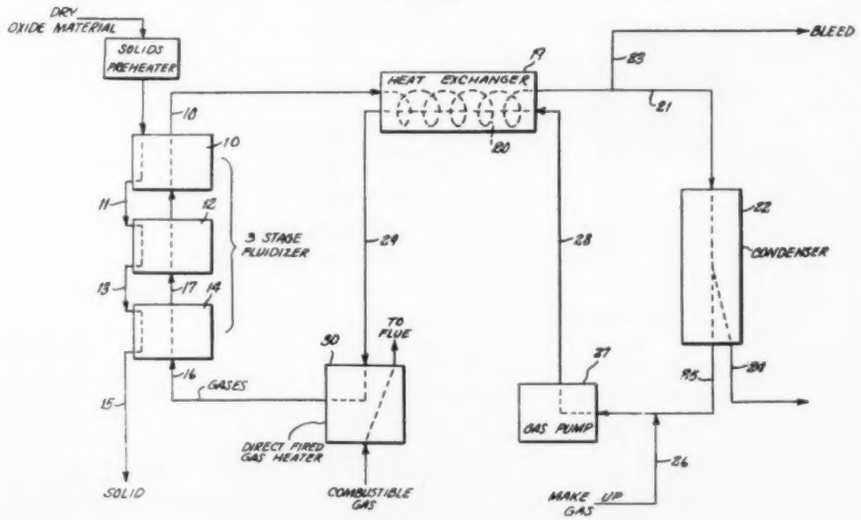
The starting material for the process may consist of any suitable oxide or mixture of the oxides of iron having a particle size of not larger than about 200-mesh and having a total content of acid-insolubles of not over about 1 per cent. It is contemplated, for example, that this material may be comminuted mill scale, wherein the problem of acid-insolubles is not present, as the material is a relatively pure iron oxide by-product from iron and/or steel manufacturing operations.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,943,368	7/5/60	Semi-automatic machine for the centrifugal casting of cylinder liners	Regie Nationale des Usines Renault
2,943,369	7/5/60	Centrifugal casting of pipe	United States Pipe & Foundry Co.
2,943,387	7/5/60	Circumferential welding of steel pipe	Lukens Steel Co.
2,943,388	7/5/60	Method of making corrosion resistant clad steel plate	Lukens Steel Co.
2,943,895	7/5/60	Packing for cylinder liners	United States Steel Corp.
2,943,911	7/5/60	Coke oven by-product recovery	United Engineers & Constructors, Inc.
2,943,930	7/5/60	Scrap refining process	Proler Steel Corp.
2,943,932	7/5/60	Boron-containing ferrous metal having as-cast compacted graphite	General Motors Corp.
2,944,309	7/12/60	Rotary field drill-mold	Otto Schaaber
2,944,310	7/12/60	Continuous casting of metals	Bruno Tarmann
2,944,666	7/12/60	Ore beneficiation	The M. A. Hanna Co.
2,945,759	7/19/60	Measuring the strength of sintered ferrous articles	General Motors Corp.
2,946,103	7/26/60	Hot tops	Enn Vallak
2,946,248	7/26/60	Cooling and transfer table	Moeller & Neumann G.m.b.H.
2,946,655	7/26/60	Recovery of ammonia from coke oven gas as diammonium phosphate	Koppers Co., Inc.
2,946,734	7/26/60	Contact element for electrolytic processing of wire	United States Steel Corp.
2,947,075	8/2/60	Continuous casting of metal strip	Aktiengesellschaft der von Moos'schen Eisenwerke
2,947,388	8/2/60	Metallurgical control during sintering	The Goodyear Tire & Rubber Co.

It has been found, according to the present invention, that the temperature range for operating with very fine material must be kept down substantially below those temperature ranges which have been conventional in the fluidized bed reduction of iron in accordance with the prior art teachings. In the present instance the temperatures in all except the last stage, i.e., in the reaction chambers 10 and 12, must be within the broader limits of about 900 to 1200 F. At temperatures below 900 F. the reaction is so slow as to be commercially impracticable. On the other hand, at temperatures above 1200 F, the tendency for the very fine particles to adhere or sinter together becomes so great that the proper operation of the fluidized bed with this fine material becomes impossible. The temperature range in the last stage, where the material is very largely iron, must be kept within somewhat narrower limits, i.e., from about 1000 to about 1100 F. The reasons in this case are substantially the same as for the other stages, except that the tendency to sinter in the last stage is now much more severe than in the case of the relatively little reduced material pres-

Figure 7

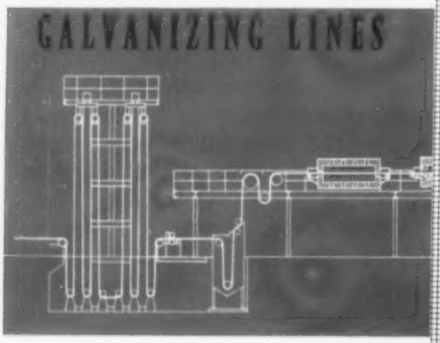


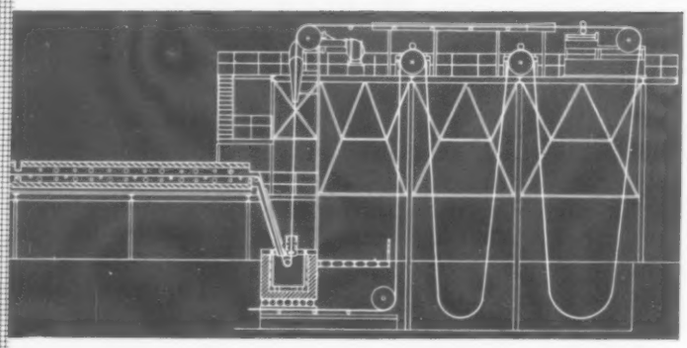
FURNACES AND HEATING EQUIPMENT

General view of two galvanizing lines constructed for S.A. Phenix Works at Flemalle-Haute (Belgium).

HEURTEY

HEURTEY - SENDZIMIR CONTINUOUS WIDE STRIP GALVANIZING LINES





world references

PARIS - LIEGE - LYONS - MADRID - MILAN - VÄSTERÄS

HEURTEY constructed in FRANCE, BELGIUM and LUXEMBURG a large number of SENDZIMIR lines either as straight or as recuperative furnaces for a range of production of 3 - 10 t/h. Identical lines can also be designed for a production up to 20 t/h.

HEURTEY

38, AVENUE GEORGES MANDEL · PARIS

KLÉ. 48-00 +

A. 187 ang. - PUB JMRabec

ent during the earlier stages.

The reducing gas primarily consists of hydrogen. After being heated, as shown, they pass from one of the fluidized bed reactors to another. Recovery of the gas includes bleeding excess gases from the system, addition of fresh gases, and condensing water vapor out of the gases, as well as heat exchange.

PREVENTION OF IRREGULAR SEALING OF FERROUS METALS

△ U. S. 2,943,961, issued July 5, 1960 to James L. Ma and assigned to Lukens Steel Co., describes a method of preventing alligator scale formation on the backing steel of a clad plate.

An aqueous mixture of magnesium chromate and calcium oxide is coated onto the plate. The coating is dried, and the plate is annealed at 1950 F.

PRODUCTION OF NEW SULPHURIC ACID FROM WASTE PICKLE LIQUOR

△ U.S. 2,946,659, issued July 26, 1960 to Charles B. Francis and assigned to Puriron & Chemicals, Inc., describes a method of producing sulphuric acid by heating particulate ferrous sulphate mixed with free sulphuric acid in such proportions that the acid equals at least 17 per cent by weight of the ferrous sulphate on the dry basis and at such concentration that the sulphate in the mixture is insoluble in the acid at 212 F.

The mixture is subjected to a current of an oxygen-containing gas to a temperature above 212 F and below that at which the acid is volatilized, thereby evaporating only water and producing dry basic ferric sulphate. The dry basic ferric sulphate is then heated to above its decomposition temperature, to produce ferric oxide and sulphur trioxide. The sulphur trioxide is reacted with water to form sulphuric acid.

PELLETIZING ORE CONCENTRATES

△ U. S. 2,947,026, issued Aug. 2, 1960 to Fred D. DeVaney and assigned to Erie Mining Co., provides apparatus for forming moist finely divided ore fines into balls.

According to the present invention, the formation of the moist particles into small balls or pellets is effected on a specifically prepared rolling surface—as distinguished from a clean metal surface. Moist particles of mineral solids are permitted to adhere to the inner peripheral surface of the balling cone, to the formation over it of a compacted bed or layer. The thickness of such compacted layer is limited to a predetermined arbitrary value. Simultaneously its upper (outer) surface is prepared by continuously doctoring (i.e., scraping) it at a number of relatively narrow, separate areas, and progressively shifting the zone of doctoring longitudinally of the balling vessel so as to effect eventual doctoring of the entire area of the compacted layer adhering to the sloping walls of the balling cone, thereby maintaining over the surface a condition of controlled roughness, promoting positive rolling of the moist material over it.

The revolutionary Bliss Pulsation Burner

produces temperatures never before achieved with oil or natural gas.Burning oil, it can reach a searing 3450°F. On 1000 BTU/cu. ft. natural gas, it develops 3320°F. Both these extremely high temperatures are close to the theoretical limits for these two fuels. Foundries, smelters, heat treaters and other metal processers have been quick to take advantage of the remarkable combustion efficiency of these new burners. To them, it has meant faster heating cycles, cleaner flue gases, and above all, fuel economy that cuts from 12% to 30% from their furnace overhead. Not to speak of reduced maintenance on refractory linings.

To learn how the Bliss Burner can increase the heat output in your plant while it's saving you money in fuel and furnace maintenance, write today for our Bulletin No. 60. It's yours for the asking.

BLISS SINCE 1857

E. W. BLISS COMPANY
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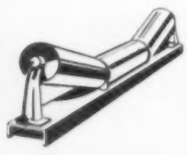
BLISS is more than a name—it's a guarantee

Here's How To Handle Hot Sinter Problems!

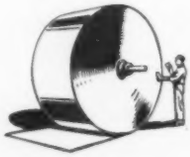
Heat, abrasive dusts, and continuous heavy loading pose special problems in sinter plant operation. Specially engineered Hewitt-Robins equipment, such as this conveyor moving hot sinter to the blast furnaces of a Western steel mill, provides dependable sinter plant operation month after month. Other H-R sinter plant equipment includes:

- Belt Conveyors—Resist abrasion, high temperatures, and withstand the impact and tension of heavy loads and long runs.
- Jones Drives for Feeder Tables—Provide dependable power transmission where continuity of operation affects the entire plant.
- Hot Sinter Screens—Efficiently screen fines with minimum degradation, resist exposure to heat, and give long life in handling abrasive sinter.
- Belt Cleaners—Eliminate a major maintenance job; improve idler and pulley life by keeping conveyor belts clean.

The rugged efficiency of H-R sinter plant equipment is found in all H-R equipment for the steel industry. For full details consult your H-R representative, or write Hewitt-Robins, Stamford, Connecticut. Ask for Bulletin 12-60.

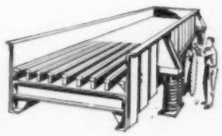


IDLERS



CONVEYOR BELTING

SPEED REDUCERS



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THE NAME THAT MEANS EVERYTHING IN BULK MATERIALS HANDLING SYSTEMS...

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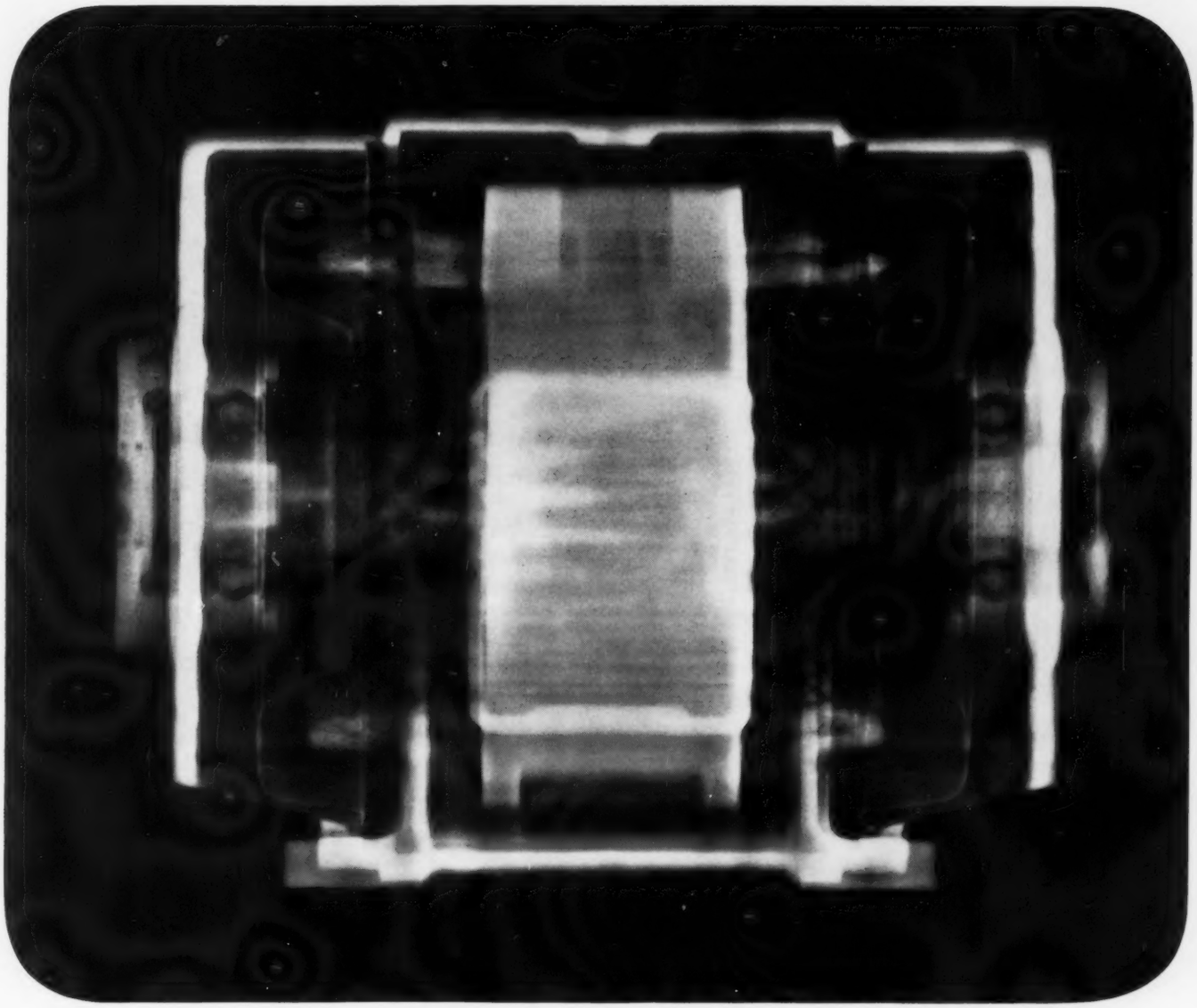
ALLIS-CHALMERS

A-1337



Actual radiograph of a 5-hp open-type motor taken with a 24-million volt Allis-Chalmers Betatron.

X-ray view of motor health

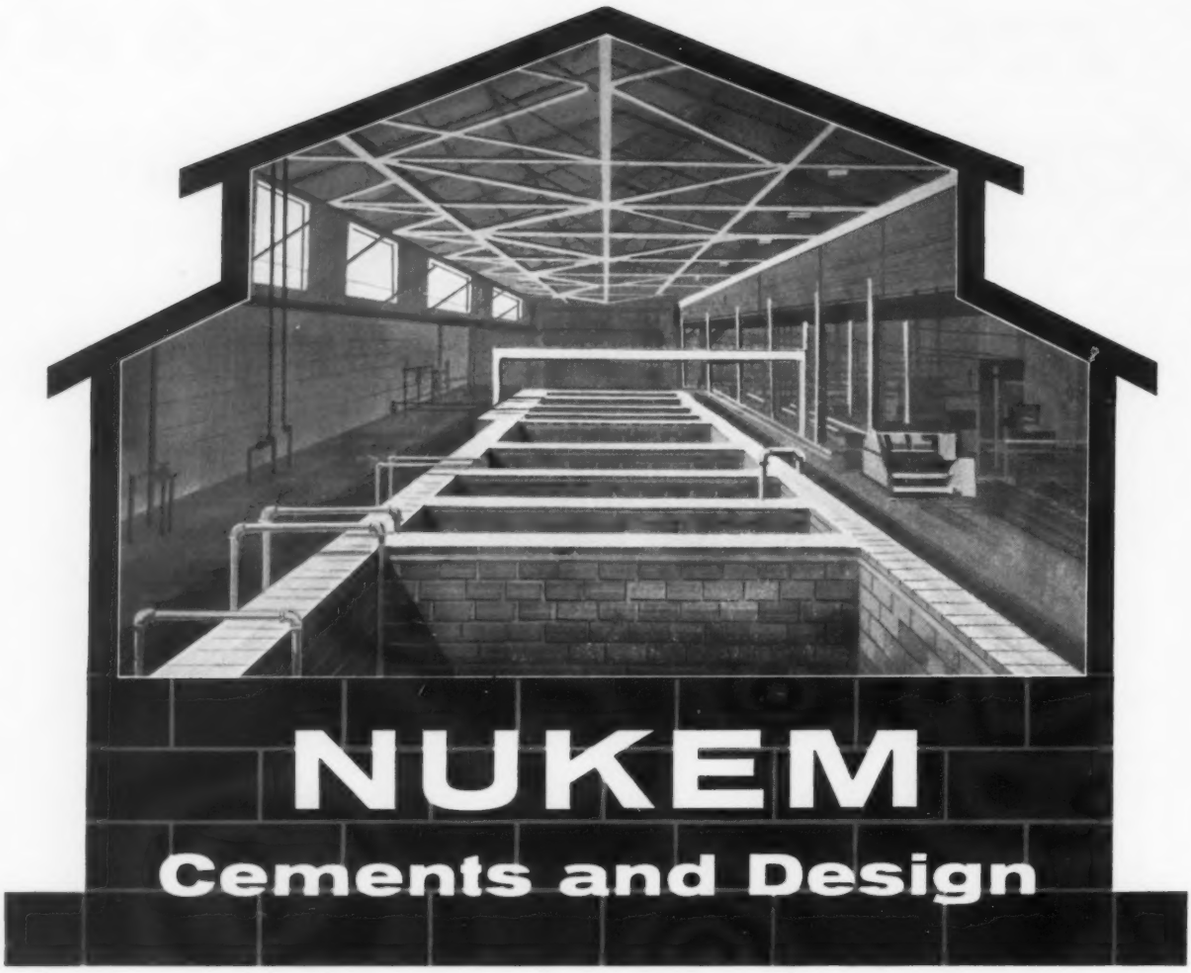
Invisible standards of perfection increase life expectancy of every Allis-Chalmers motor

The exceptionally long performance of A-C open motors proves the value of thinking *beyond* established standards of design . . . of taking "significant new achievement" as the ideal.

This ideal led to many refinements for A-C open motors: double-shielded bearings that keep dirt out and allow controlled migration of grease, permanently numbered lead spacer and leads for easy identification and connection, and heavy-duty cast iron frames that resist corrosion and keep rotating parts perfectly aligned.

For totally-enclosed, open-type and *Super-Seal* general purpose motors, and electrically or mechanically modified definite-purpose motors, choose the motor built to invisible standards of perfection. Choose A-C. Special application help available.

Call your nearby A-C representative. Or write **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wis.* Super-Seal is an Allis-Chalmers trademark.



...add years of service to your tanks and foundations

Sulphuric, hydrochloric, nitric or hydrofluoric acids... nickel salts or caustics... no matter what corrosive solutions your processes require, there is a Nukem cement designed for your service.

For over 35 years, Nukem has specialized in the manufacture of a complete line of acid and/or alkali proof cements and linings—each bearing the hallmark of "top quality." Over this same period—employing these products—the name NUKEM has been associated with successful, reliable, corrosion proof construction of Pickling Tanks, Neutralizing Systems, Foundations, Manholes, Trenches and Sewers.

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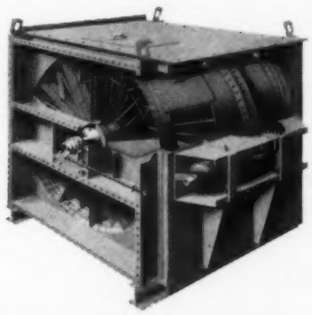
NEW...FOR STEEL PROCESSING FURNACES

continuous regenerative Air Preheaters



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1 The Ljungstrom® Metallic Rotary Regenerative Air Preheater has had widespread use in this country, in the industrial and utility fields since 1925. Over 3500 units are now in operation. These include those of high temperature alloy design for refinery installations.

2 Now we are prepared to apply our regenerator to steel plant furnaces, particularly to proposed reheat furnaces and soaking pits. Because of its compactness and layout flexibility, the Ljungstrom also might well be considered for up-grading existing furnace capacities by raising preheated combustion air temperatures.

3 For your study and analysis, we would like to offer our services in selecting a suitable preheater and submitting its performance and cost for any given application. To accomplish this, we request that you send us the following data:

1. Type Furnace_____
2. Fuel Type_____ Heating Value_____ Cost_____
3. Fuel Rate . . . BTU/HR_____
4. Ambient air temperature . . . °F_____
5. Flue gas temperature . . . °F_____
6. Desired combustion air temperature . . . °F_____

How Morgan stress relieving insures maximum design strength

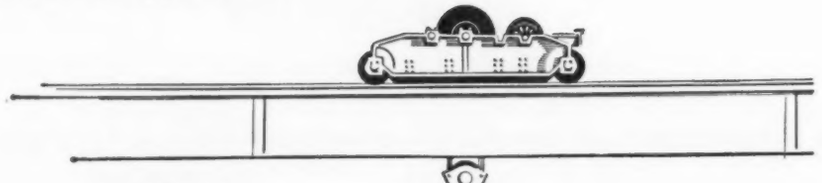
● STRESS RELIEVING is one of many reasons why Morgan cranes provide longer, completely safe service under *any* operating conditions. Trolley frames, end carriages, trucks, drums, bearing caps, stripper barrels and rams, pit rams . . . all are stress relieved in Morgan's huge furnace capable of handling loads up to 250,000 pounds.

Morgan's stress relief furnace, one of the largest in the world, can raise temperatures 200 degrees Fahrenheit per hour up to 1750° F.

Stress relieving is still another example of the advanced design and construction features that make Morgan cranes the best in the business.

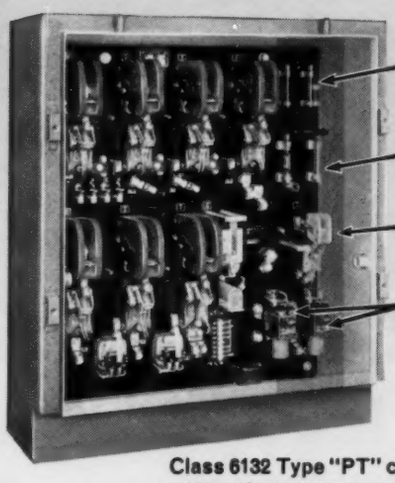
Performance records prove that Morgan cranes cost less to operate and maintain. Let our representative show you how to save the most by buying the best . . . Morgan!

● Stresses built up in welding process are relieved in this 52 x 20 x 15 foot furnace. The 48 dual fuel burners are divided into three temperature zones, each zone controlled by an electronic potentiometer. Safety devices include high limit temperature controls, fuel shut-off valves. Combustion safeguards insure against over-heating.



The Morgan Engineering Company, founded in 1868, manufactures overhead electric traveling cranes, gantry cranes, open hearth special cranes, plate mills, blooming mills, structural mills, shears, saws, and auxiliary equipment.

THE MORGAN ENGINEERING CO. *Alliance, Ohio*



Class 6132 Type "PT" controller with self-contained protection

NOW! LOW-COST MAGNETIC CONTROL FOR DC CRANES

Compact EC&M Type "PT" Control—*a logical replacement for manual control*

• On any DC crane application up to 55 hp, 230 volts, you now can have all the advantages of *full magnetic* control where manual control formerly was purchased purely on the basis of price. Whether you're modernizing existing cranes or ordering new ones, you'll find type "PT" control far superior to manual control.

Space Saving • compact controllers fit easily in crane cabs, on crane walkways and in congested areas for other mill applications. Front connection permits mounting against walls or girders.

Full Protection • *now* available with self-contained undervoltage and overload protection. Also supplied without protection for use with separate protective panel.

Extra Safety • Exclusive Wright dynamic lowering circuit is the simplest and safest circuit for crane hoist service, gives maximum hook speed without danger of overspeeding. Controller completely enclosed.

Automatic Acceleration • relays adjustable from 0.2 second or more per step. Automatic acceleration reduces wear on motors and control.

Plugging Protection • rectifier-type plugging relay operates from motor counter-emf.

Choice of Master Switches • dynamic lowering controllers furnished with 4-point speed control. Choice of 3 or 4 point master switches on reversing plugging controllers.

Heavy-Duty Construction • mill-type contactors, sturdy design throughout make Type "PT" control suitable for mill accessory drives as well as light industrial cranes. Available in NEMA Type 1 general purpose, Type 1 gasketed, or NEMA Type 3 weatherproof enclosures.

Write for Bulletin 6132 for details on "PT" control with protection

SQUARE D COMPANY

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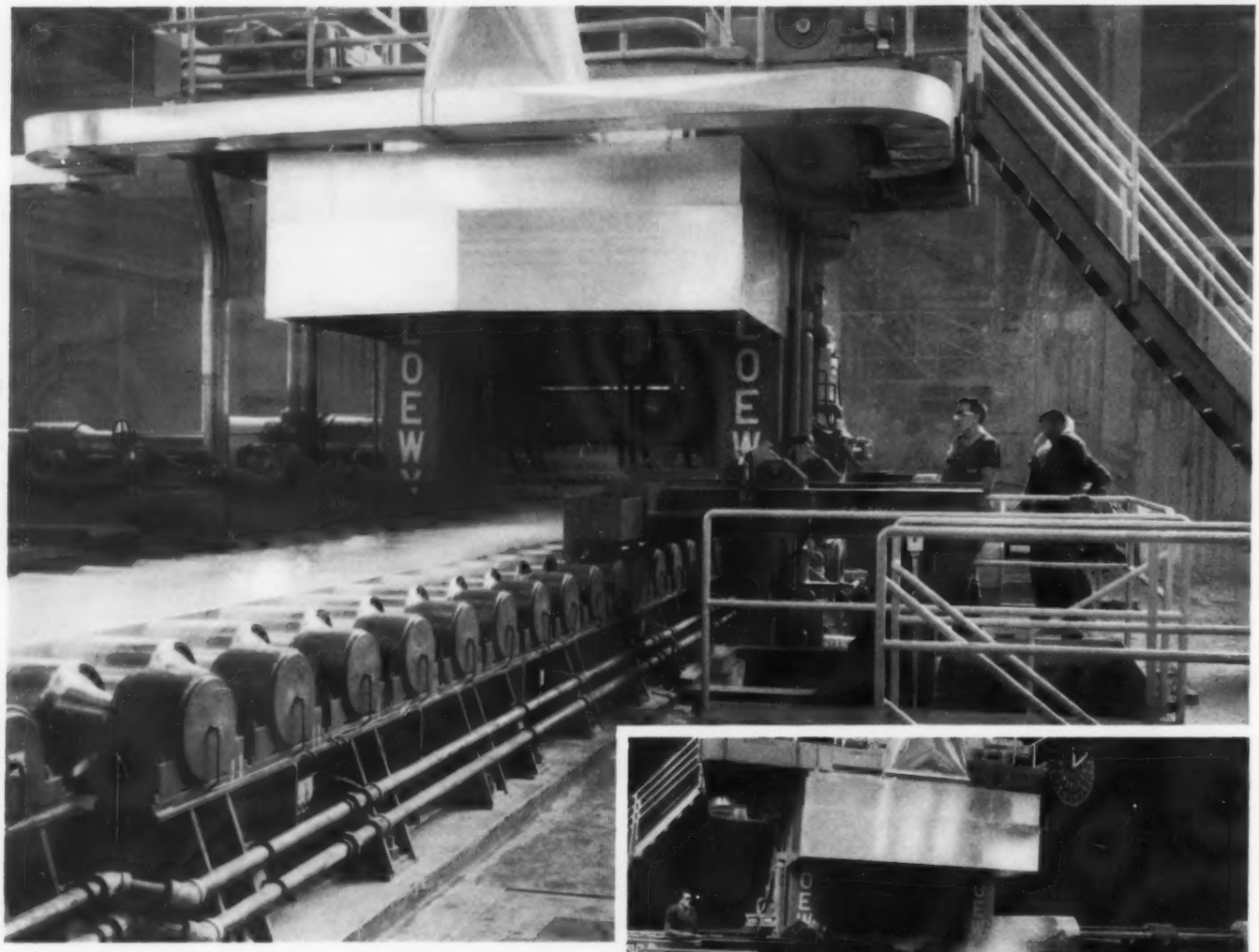

Loewy two-high 32 in. x 72 in. reversing hot breakdown mill seen from exit side.

As seen from entry side.

New B-L-H Loewy mill rolls 5000-lb. slabs to 3/16 in., produces 120 ingots in 8-hr. shift

B-L-H has recently put into operation a new hot reversing two-high Loewy breakdown mill. It is part of a fully integrated Loewy rolling mill installation at a new 12-million-dollar plant in the Great Lakes area. Designed to the customer's production requirements, this mill rolls 5000-lb. slabs to 3/16 in. reroll stock and has a production capacity of up to 120 ingots in one 8-hour shift.

If you are in the market for special machinery built to the most exacting demands or for an experienced organization to handle a turnkey project, contact Baldwin-Lima-Hamilton, Dept. C-12.

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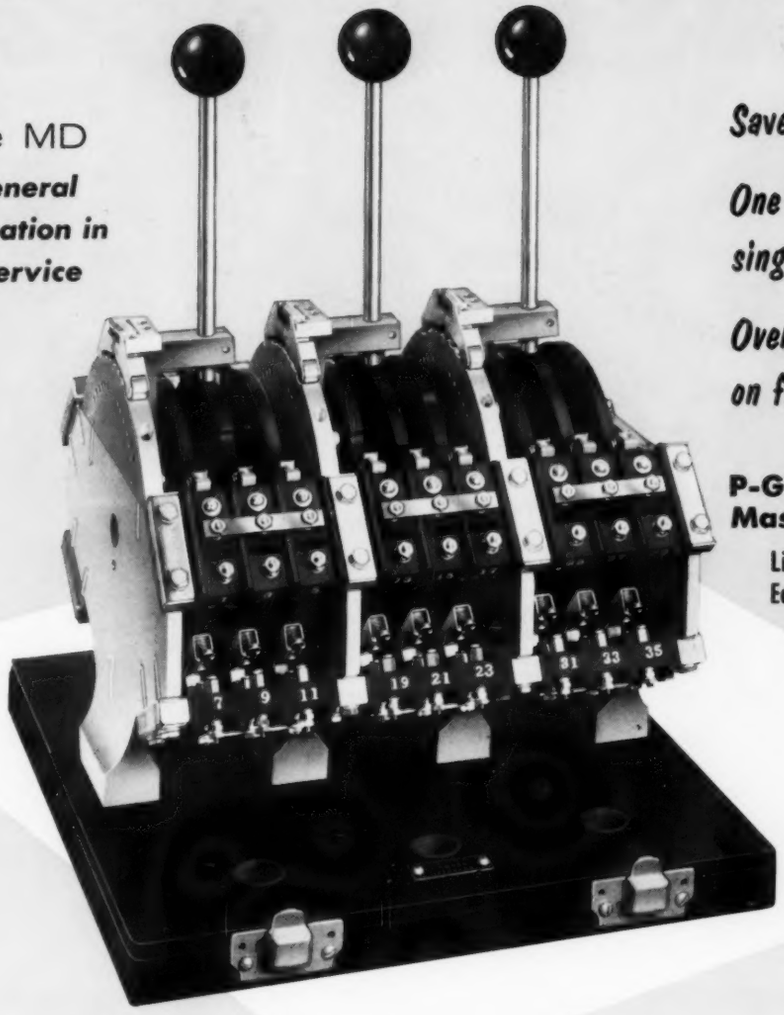
Type MD

for general application in Mill Service



Save valuable mounting space

One to four switches in a single enclosure

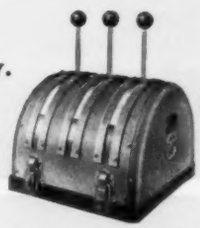
Overall length less than 22" on four unit switch

P-G *Improved*
Master Switch

Lighter in weight
Easier to wire

P-G master switches

Unique in design, the Post-Glover Type MD Master Switch saves valuable mounting space in crowded crane cabs or mill pulpits where sufficient room has always been a problem. Each single Master has a maximum of 12 circuits and up to 6 points either direction. The operating lever has exceptionally short angular travel and can easily be adjusted in length, thus adding to operator comfort and efficiency.



Enclosure easily removed.

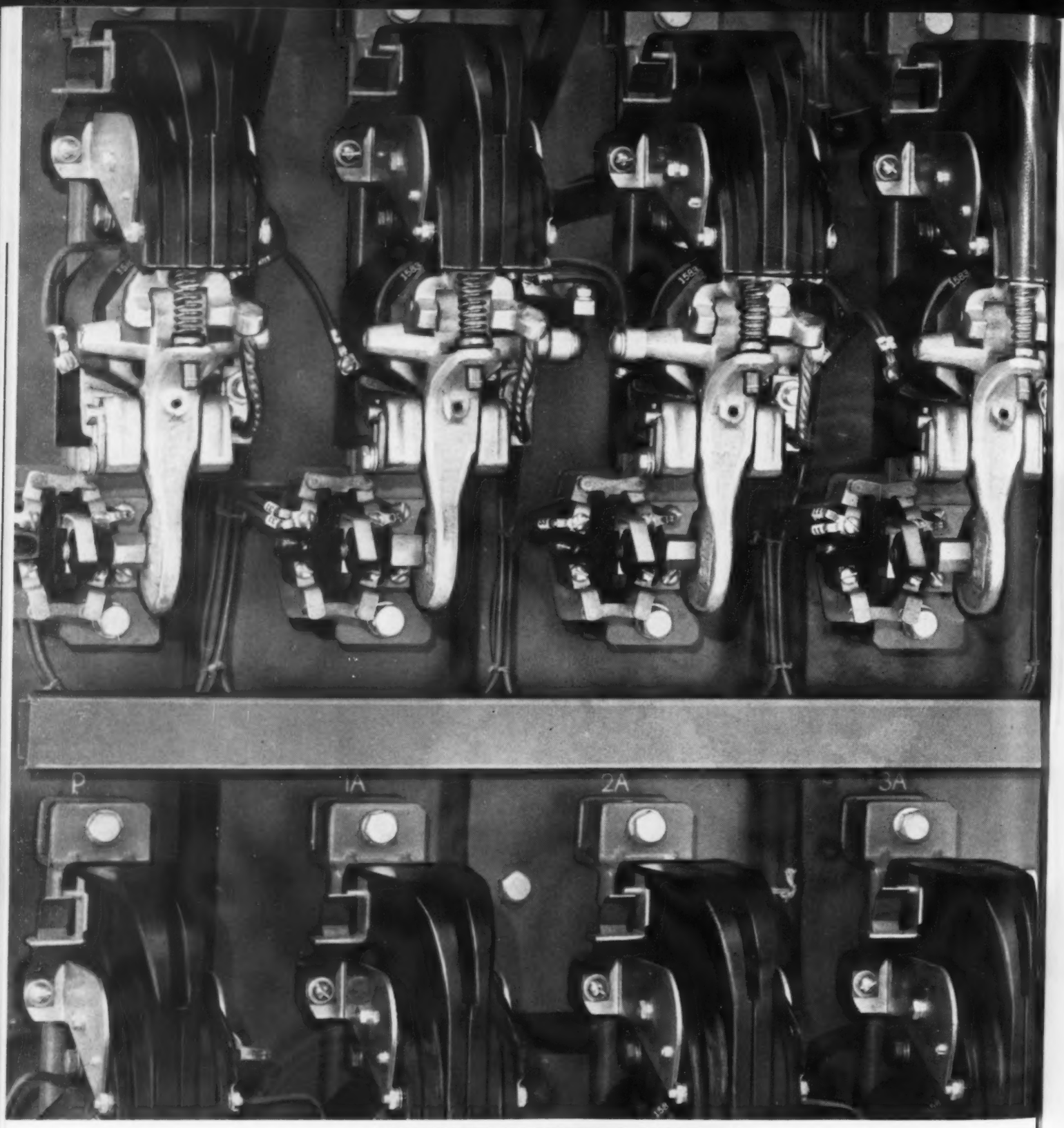
Write for Bulletin 410

THE **POST-GLOVER** ELECTRIC COMPANY

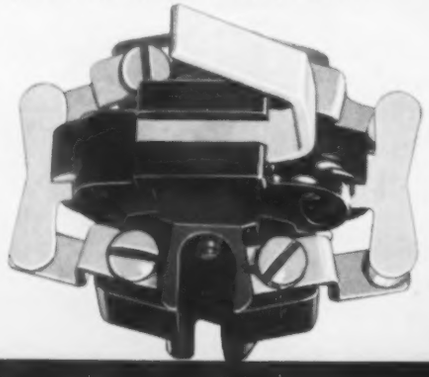
Established 1892

Office and Factory—KENTON LANDS ROAD, ERLANGER, KENTUCKY

Mailing Address—BOX 709, COVINGTON, KENTUCKY

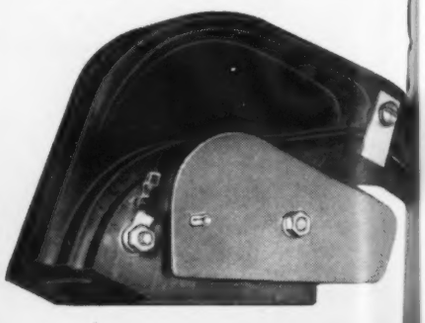


Pre-drilled mounting holes on unit base accommodate electrical interlock assemblies with field convertible contacts.



Bus bar or wiring can go behind elevated contactor. Saves panel space.

New improved arc chute increases contact life.



Now! More compact front wired control panels with new Cutler-Hammer D-c contactors!

Six sizes with new mounting flexibility for the control panel you need: 25, 50, 100, 150, 300, and 600 amperes

Cutler-Hammer's new line of D-c unitized contactors gives you the flexibility of mounting you need . . . in panels built for you by Cutler-Hammer or panels you assemble.

Every contactor is assembled on an insulated steel base, so all that's needed is two bolts to attach it to a steel or slate panel. Wire them from the back or from the front. Surface mount them or elevate them with spacers. Elevated mounting and front wiring give the ultimate in space saving and ease of maintenance.

This rugged new line has been thoroughly tested to give you the typical long-lived performance of all Cutler-Hammer control. Coils are impregnated with epoxy resin for complete protection against moisture and dust. Improved blow-out structure increases contact life even more.

What's new at Cutler-Hammer?
The new line of unitized contactors is just another step to keep Cutler-Hammer your best source for heavy duty mill control equipment. Wherever you look you can see the new spirit—in new, better products, new manufacturing facilities, new engineering talent—all designed to serve you better in the big years ahead. Get all the facts about Cutler-Hammer. Ask your Cutler-Hammer distributor, Cutler-Hammer sales office or write direct for Pub. LO-80-Y232 which tells about unitized contactors.

WHAT'S NEW? ASK...

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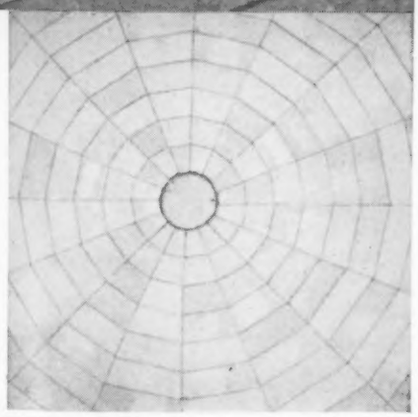
Bell-type annealing furnaces hold critical temperatures better—using J-M Superex

LEE WILSON ENGINEERING COMPANY, INC., STANDARDIZES ON J-M SUPEREX BLOCK INSULATION FOR PRECISION AND PERFORMANCE

In heat-treating furnaces, at temperatures to 1900F, Johns-Manville Superex® Block insulation provides greater efficiency and long operating life . . . because of its unique combination of low conductivity and low shrinkage at elevated temperatures. Control of critical processing temperatures is reached *and held* more easily.

Especially formulated from diatomaceous silica and asbestos, the large, strong, lightweight blocks of J-M Superex are cut with such careful precision that a furnace dome will support the weight of several workers during construction...*without any cement being used!*

This ideal combination of performance advantages and production skill is the reason Lee Wilson Engineering Co., Inc., employs J-M Superex for wall and dome insulation. It will pay you to insist on J-M Superex in your high-heat equipment. Write for details to Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada: Port Credit, Ont. Cable: JOHNMANVIL.



Inside Looking Up ...*view from below the dome of a Lee Wilson bell-type furnace. Note close fitting between Superex blocks. This dome actually supports installation workers' weight* . . . without use of cement!

ONLY J-M SUPEREX BLOCK INSULATION GIVES YOU ALL THESE ADVANTAGES:

High Compressive Strength – only ⅛" compression under 85 lbs psi

Low Conductivity – .82 at 1000F mean temperature

Low Heat Shrinkage – 2.7% linear shrinkage at 1900F

Large Size Blocks – 12" x 36" blocks speed application, reduce number of joints. Yet blocks are light in weight for ease of installation

Lightweight – only 24 lbs per cubic foot

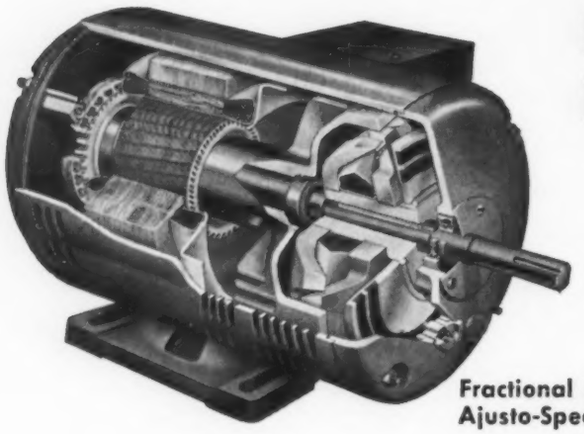
JOHNS-MANVILLE

AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

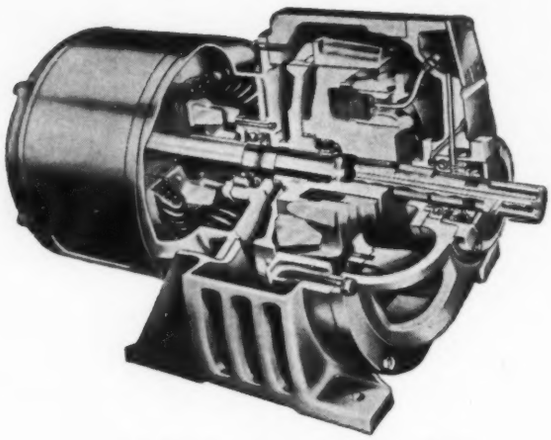
JOHNS-MANVILLE JM PRODUCTS

Bring Your Speed Control Problems to

EDDY-CURRENT HEADQUARTERS



Fractional HP
Ajusto-Spede Drive



Air-Cooled Ajusto-Spede Drive

EATON
DYNAMATIC

Let Our Years of Speed Control Experience Go to Work for You!

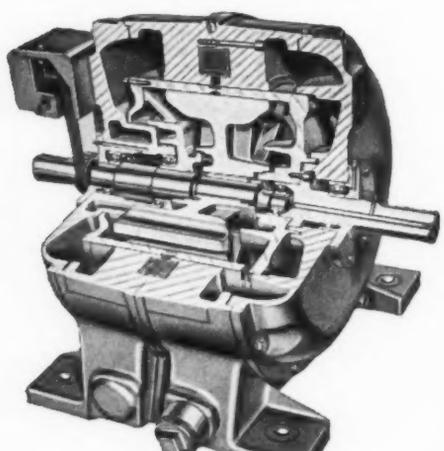
30 years ago Dynamatic pioneered the utilization of eddy-currents in industrial rotating equipment. Today, the Dynamatic Division of Eaton Manufacturing Company is the recognized leader in the development and production of eddy-current drives, couplings, brakes, and dynamometers—equipment which is solving production problems in every major industry.

In speed control applications, Eaton-Dynamatic Eddy-Current Equipment offers many exclusive advantages—stepless adjustable speeds from AC power, rapid response, wide speed range, quiet operation, low power loss, low maintenance cost, remote control, simple electronic or transistorized control.

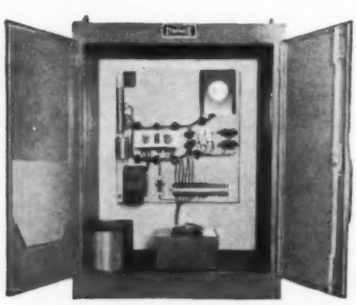
Dynamatic Eddy-Current Equipment is available in sizes from 1/4 hp Ajusto-Spede Drives to heavy-duty couplings rated up to 20,000 hp—and larger.

When you have a speed control or drive problem, bring it to "Eddy-Current Headquarters"—we can provide a simple, economical solution.

Write for Illustrated Descriptive Literature



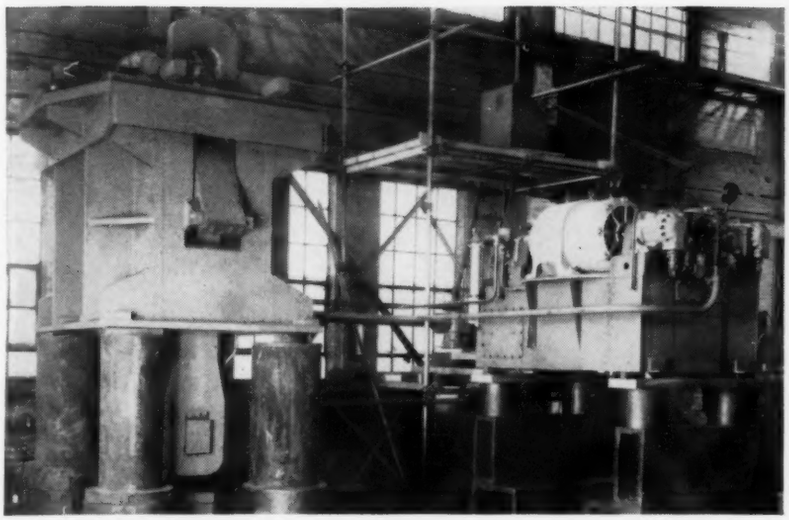
Magnapower Heavy-Duty
Liquid-Cooled Coupling



Magnetic Amplifier (Transistorized)
Control

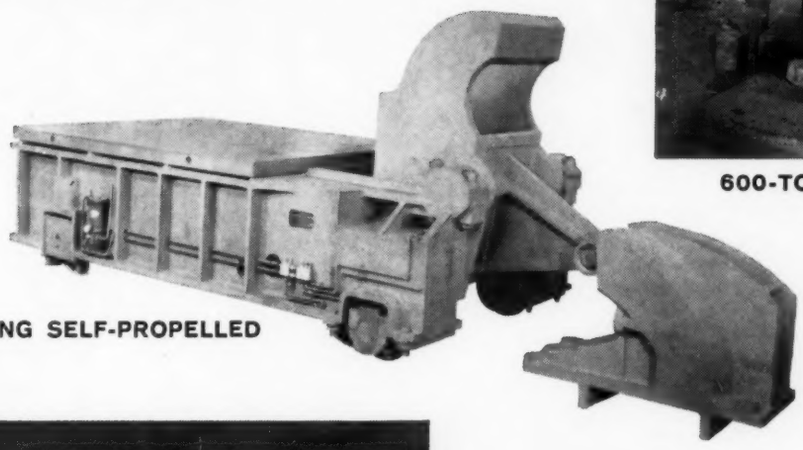
EATON

EATON — DYNAMATIC DIVISION
MANUFACTURING COMPANY
3122 FOURTEENTH AVENUE • KENOSHA, WISCONSIN



800-TON INGOT STRIPPER

600-TON INGOT STRIPPER



FORWARD-TILTING SELF-PROPELLED INGOT BUGGY

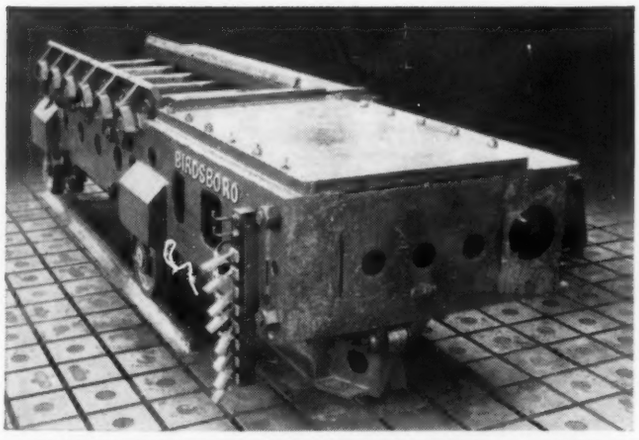
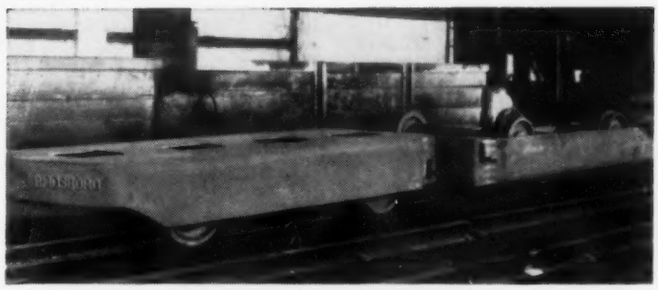


TABLE-TYPE SELF-PROPELLED INGOT BUGGY



INGOT TRANSFER CARS

SIDE-DUMP INGOT BUGGY

Ingot Handling Equipment *designed and built by*

MM 85-60

BIRDSBORO
CORPORATION

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • ROLLS
ELECTRIC STEEL CASTINGS: Carbon, Low Alloy and STAINLESS STEEL • BIRDSBORO, PENNSYLVANIA

You seldom need this sign

Youngstown safety limit stops protect against overhoisting accidents, provide positive check against human errors.

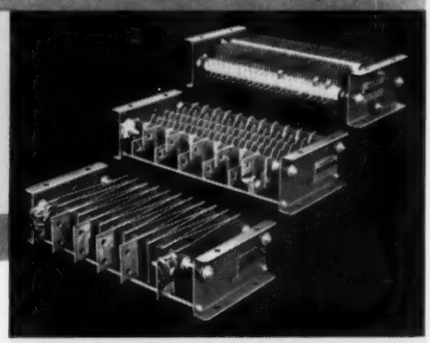
Write for Bulletins on any or all EC&M controls. They give complete descriptions of equipment and explain why EC&M control keeps cranes operating at top efficiency. Square D Company, EC&M Division, 4500 Lee Road, Cleveland 28, Ohio.

SQUARE D COMPANY

EC&M DIVISION • CLEVELAND 28, OHIO

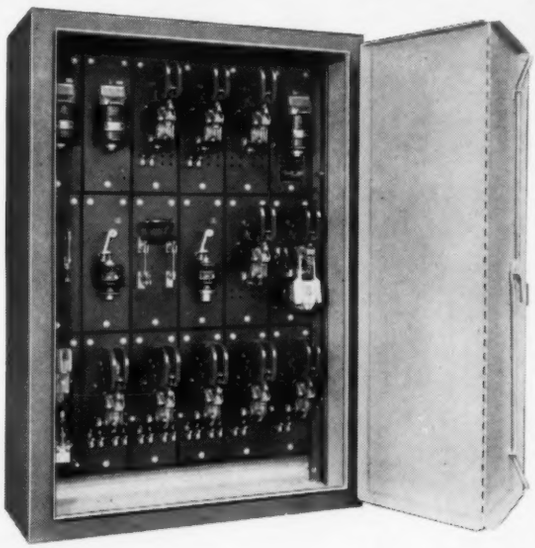
when your cranes are equipped

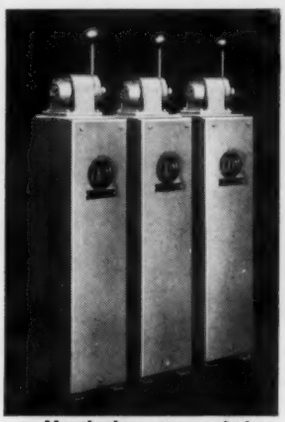
with EC&M CONTROL



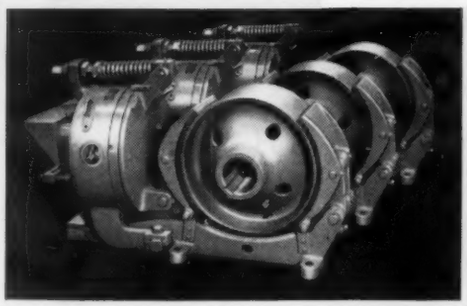
Tab-Weld resistors eliminate burning at the grid eyes or tap plates. Available in capacities from 13 to 500 amperes continuous.

DC controllers are simple to maintain, provide pinpoint accuracy and safe operation.

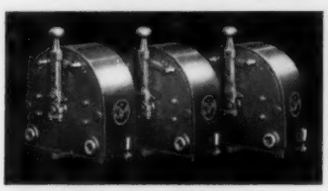




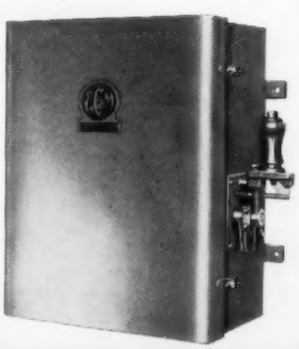
Vertical master switches require little mounting space. Short throw reduces operator fatigue.



Long-life brakes give high-speed performance, have 100% lubrication so that dirt can be flushed out.



CM master switches have short throw of operating handle and narrow width for close grouping.

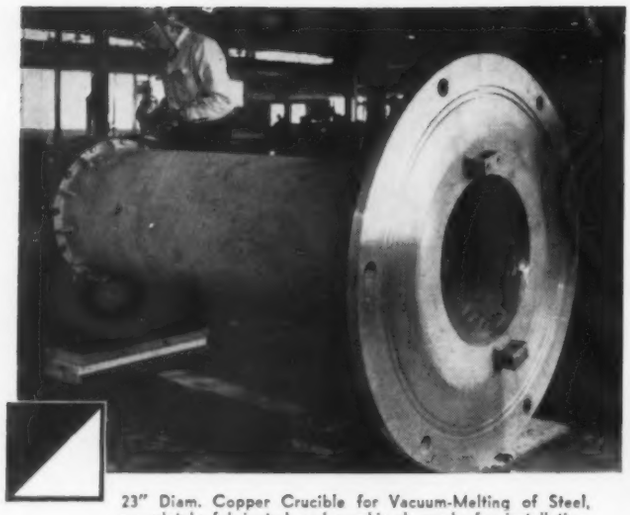


Manual-magnetic disconnect switches provide a convenient and quick means of "killing" the crane, including an emergency remote-controlled STOP button.

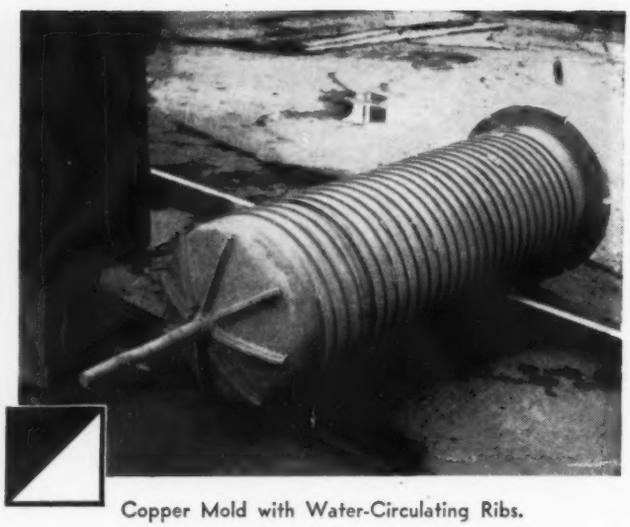
MA master switches provide a maximum of 3 speed points. Can be grouped with other masters or can be used on auxiliary drives.

WHEREVER ELECTRICITY IS DISTRIBUTED AND CONTROLLED . . . . . .

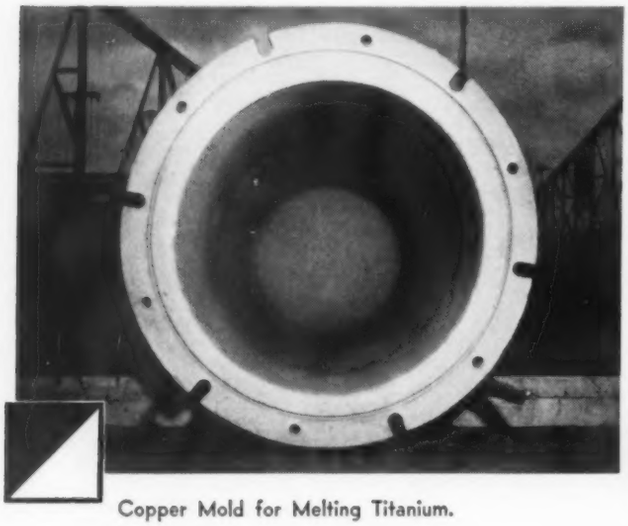
3880



23" Diam. Copper Crucible for Vacuum-Melting of Steel, completely fabricated and machined, ready for installation.



Copper Mold with Water-Circulating Ribs.



Copper Mold for Melting Titanium.

Welding Copper Ribs on Heads for Copper Crucibles.

VACUUM MELTING CRUCIBLES BY WELDCO

FOR TITANIUM AND ALLOY STEELS

We have had extensive experience in making Copper Molds, Jackets, and Furnaces for Vacuum-Melting of Alloys. Progressive producers are boosting their quality sharply by using the Vacuum-Melting Process. Why not investigate the possibilities?

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

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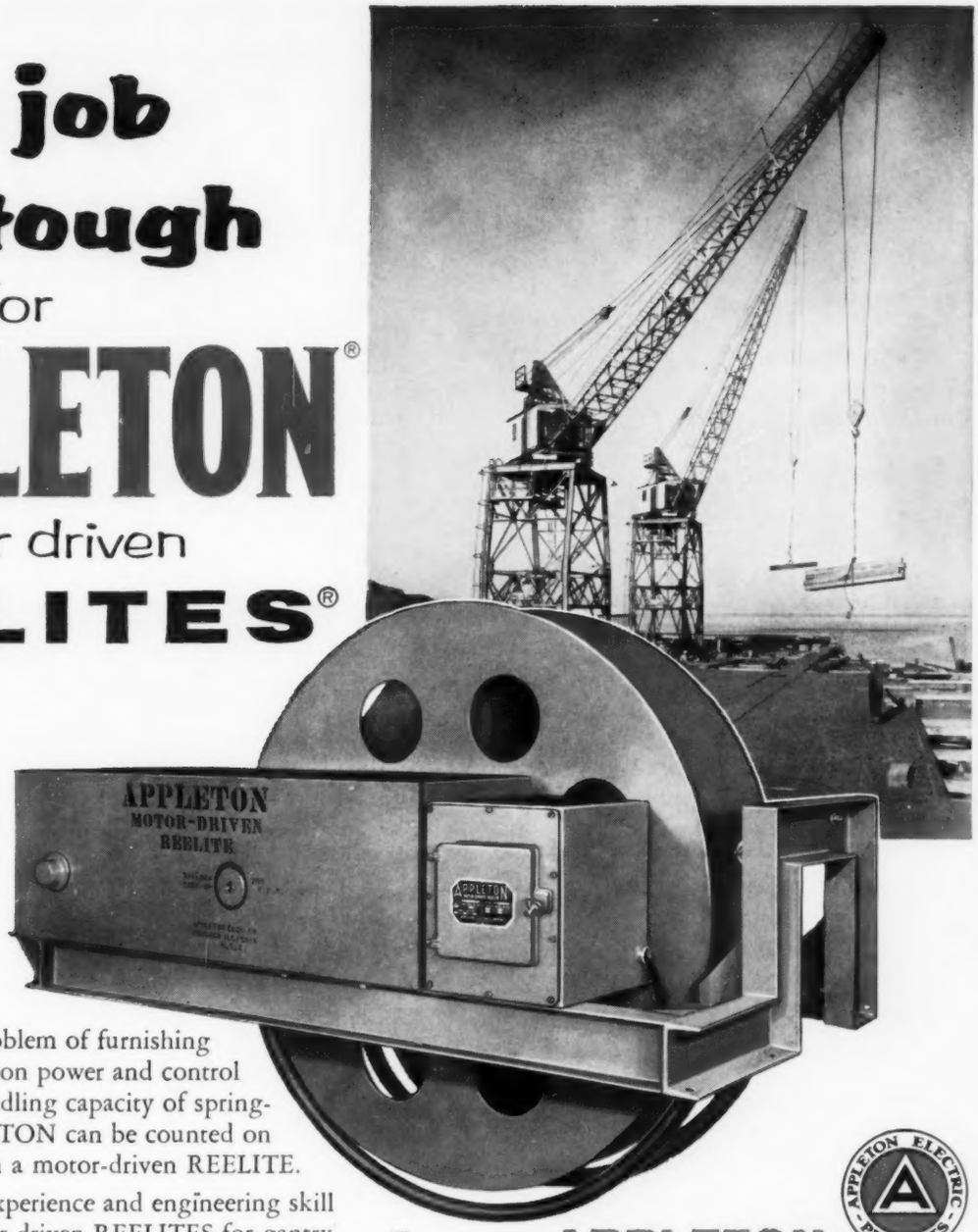
no job too tough for APPLETON® motor driven REELITES®



When it's a problem of furnishing power or combination power and control beyond the handling capacity of spring-driven reels, APPLETON can be counted on to find the answer with a motor-driven REELITE.

APPLETON'S experience and engineering skill in designing motor-driven REELITES for gantry cranes, material handling equipment, traveling bridges, magnet application, etc. is known the world over.

If you have a problem of furnishing power or combination power and control for your operation, contact your local APPLETON Field Engineering Office or write for Bulletin 505.

Only APPLETON Makes Reelites

APPLETON
Electric Company
1701 Wellington Avenue
Chicago 1, Illinois

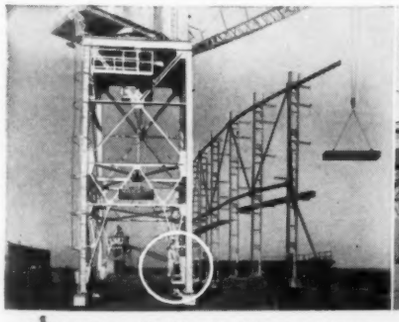
Also Manufacturers of:

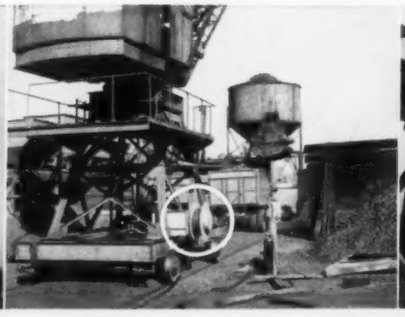
Explosion-Proof Hand Lamp

"EX" Series Flexible Couplings

Malleable Iron Unilets

Explosion-Proof Junction Unilets


Motor-Driven Reelite furnishing a source of power for a large gantry crane.


Motor-Driven Reelite installed on movable crane in large coal yard.

Typical installation of Motor-Driven Reelite applied to over-bridge travel application.

The latest development in Open Hearth Steel-making Practice

WELLMAN

Britain's foremost builders of Steel-making Plant

now offer the

AJAX Oxygen Steel-making Operation

This new steel producing technique has been incorporated in the furnace illustrated. It was invented and developed by Appleby-Frodingham Steel Company, and has already produced over 750,000 tons of ingots. A third unit has now been commissioned and a fourth is about to be reconstructed.

Outputs have been increased to over five thousand tons of ingots per week, using 100% phosphoric molten iron.

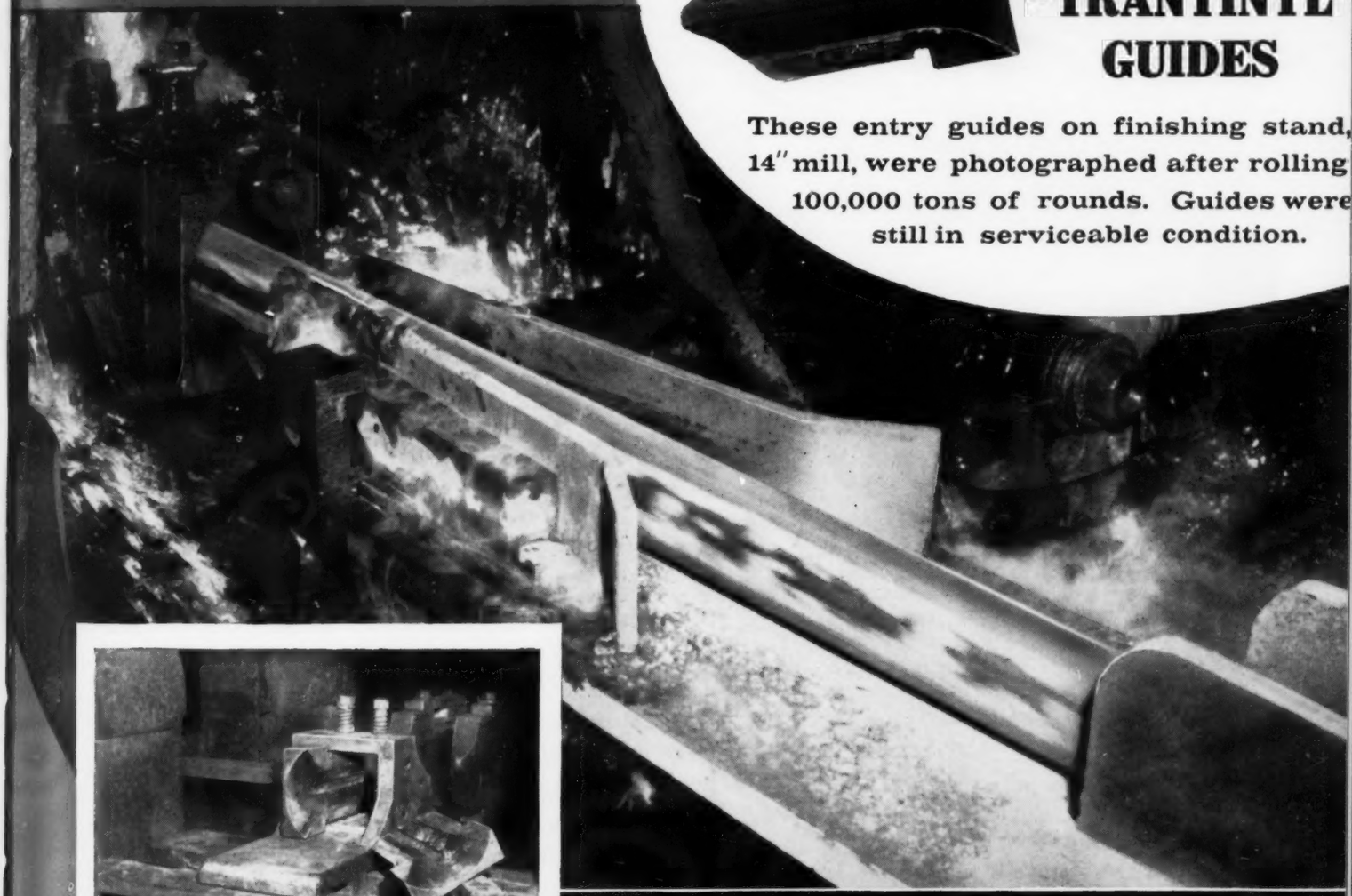
This Furnace has now over 90% availability together with lower than normal refractory costs.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION LTD.
PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1 WORKS: DARLASTON, South Staffs, & BELFAST.

TRANTINYL GUIDES THE STEEL INDUSTRY

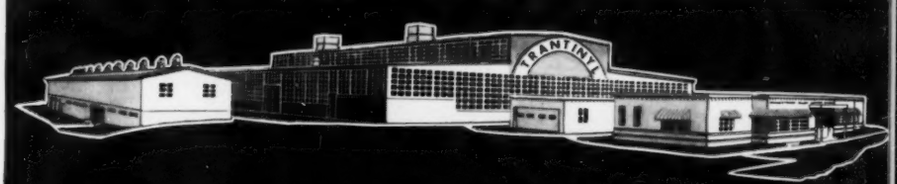
U. S. Steel Gary Works rolled 100,000 TONS with this pair of "TRANTINYL" GUIDES

These entry guides on finishing stand, 14" mill, were photographed after rolling 100,000 tons of rounds. Guides were still in serviceable condition.



14" Mill, Gary Works, with "TRANTINYL" Guides and Guide Box

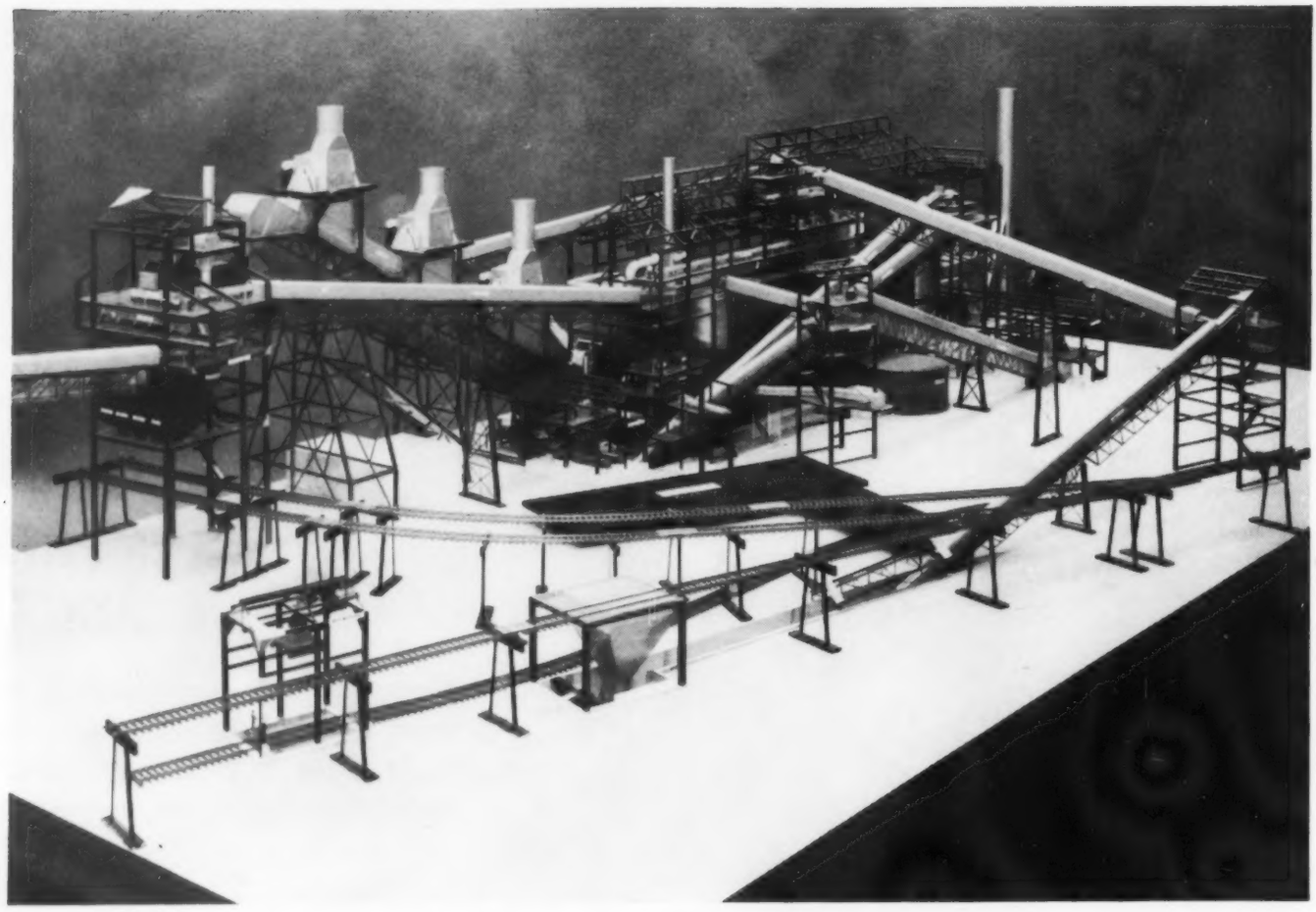
"Trantinyl" Guides and Rollers hold exceptionally high tonnage performance records, in serving leading steel mills for a quarter-century.



Youngstown Alloy Casting Corporation
Youngstown, Ohio

Sole Licensee to cast "TRANTINYL" for the Midwest, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.

G-13



Scale model of the newest Dravo-Lurgi sintering plant, now under construction for Interlake Iron Corporation.

47,500 tons per day

Dravo-Lurgi Sintering and Pelletizing Plants, some still under construction, will produce in excess of 15,500,000 tons of sinter or pellets per year.

Listed here are the major Dravo-Lurgi projects:

In Operation	For	No. Machines	Capacity
Gary	United States Steel Corp.	3	15,000 tpd
Saxonburg	United States Steel Corp.	3	15,000 tpd
Ashland	Armco Steel Corp.	1	2,400 tpd
Trenton #1	McLouth Steel Co.	1	2,100 tpd
Trenton #2	McLouth Steel Co.	1	2,100 tpd
Copper Cliff, Ont.	International Nickel Co.	1	1,100 tpd
Under Construction			
Chicago	Interlake Iron Corporation	1	3,300 tpd
Aliquippa	Jones & Laughlin Steel Corporation	1	6,500 tpd
		Total:	47,500 tpd

In addition to these complete plants, Dravo has built sinter coolers of several types for a number of existing sinter machines. These coolers are designed to reduce sinter temperatures at the maximum rate consistent with minimum shattering, and unload the cooled sinter without further breaking.

This extensive experience with sintering and pelletizing plant design and construction can be brought to bear on your specific requirements. We will be glad to discuss the latest techniques in ore agglomeration with you or your staff. Write or phone Dravo Corporation, Pittsburgh 22, Pa.

DRAVO
CORPORATION

Blast furnace blowers • boiler and power plants • bridge sub-structures • docks and unloaders • dredging • fabricated piping foundations • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

Foreign Digests

Complete translations from which these condensations were prepared are available from Henry Brutcher, P.O. Box 157, Altadena, Calif., to whom all correspondence should be addressed.

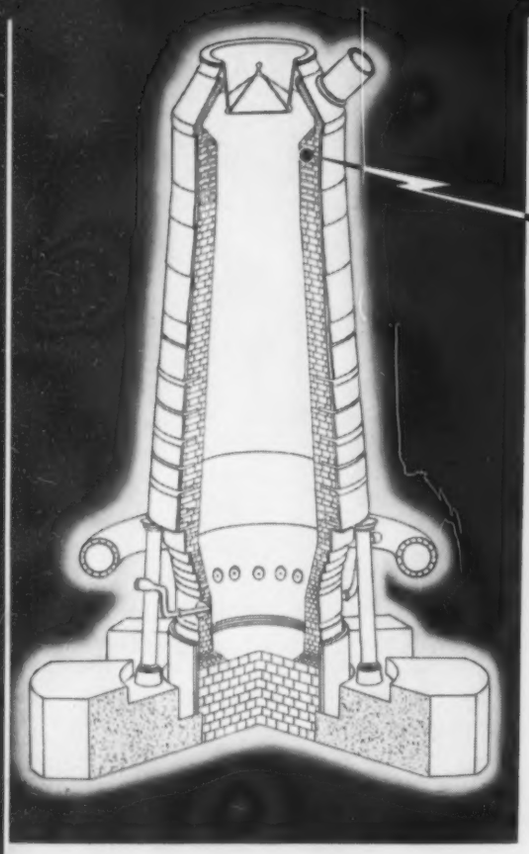
"Blast Furnace Coke-Rate and Reactivity of Coke," by G. Heynert, W. Zischkale, and E. Schürmann, Stahl und Eisen, vol. 80, 1960, No. 15, pp. 981–87. Lack of precise data on effect of different types of coke upon blast-furnace coke rate. Investigation into existence of a relationship between reactivity of coke toward carbon dioxide as determined by laboratory test and coke rate in blast furnace. Data on blast-furnace operating trials. Checking of primary records over a period of six months and conversion of coke rate per ton of pig iron to uniform reference values (to eliminate minor variations). Theoretical considerations regarding a laboratory test to be developed for the assessment of coke reactivity. Experimental laboratory setup and first results. Relationship between coke reactivity as determined in this setup on average daily samples of all cokes charged in furnace and the blast-furnace coke consumption. Effect of cellular coke structure on its quality and, hence the coke rate. (Translation No. 4889)

"Control of Reactions During the Melting and Pouring of Steel by Reduction of Pressure to Subatmospheric," by E. Schwarz-Bergkampf, Berg- und Eisenhuttenmänn. Monatshefte, vol. 105, No. 6, pp. 133–35. Exposition and amplification of the theory underlying the melting and casting of steel and prerequisites to benefits derived from the use of vacuum. Author's data and comparative literature data on carbon and oxygen contents after deoxidation of steel bath with carbon as function of partial pressure of carbon monoxide at 1600 C. Bubble and blowhole formation; effect of furnace lining. Reduction of quantity of nonmetallic inclusions by vacuum. Practicable degassing techniques. Exact time when vacuum should be discontinued during the solidification of steel. Includes general discussion. (Translation No. 4892)

"Experiments on Models as an Aid in the Study of Degassing Liquid Metals," by Th. Kraus and O. Winkler, Berg- und Hüttenm. Monatshefte, vol. 105, 1960, No. 6, pp. 135–140. Need for more information on the removal of oxygen and nitrogen from liquid steel, with special reference to rate of degassing action and over-all progress of reaction. Authors' simplified method based on principle of similarity and aiming at a solution of some important degassing problems by model experiments. Explanation of principle of similarity with respect to molecular material, heat and impulse transfers. Importance of hydrodynamic factors for material transfer through boundary surfaces of a homogeneous liquid phase, phase formation and boiling action. Results of flow experiments using supersaturated carbon dioxide solutions under vacuum. Introduction into evacuated space as function of nozzle geometry; laminar jet impinging on a liquid from various nozzles; resulting bubble patterns. (Translation No. 4893)

"Investigation of the Contamination of Oxygen Top-Blown [LD] Steel with Nonmetallic Inclusions," by V. I. Baptizmanskii and Yu. A. Dubrovskii, Izvest. Vuz-Chern. Met., Nov. 1959, No. 11. Study of the different types of nonmetallic inclusions occurring in oxygen top-blown steel as compared with inclusions in rimmed open-hearth steel, with special reference to furnace and pouring practice. Investigational procedure. Comparative contamination of different types of steel; results of petrographic examination of inclusions. Effect of furnace and pouring practice; effect of hot metal composition on dirt content of bessemer rail steel. Stable inclusions during deoxidation and pouring of rimming oxygen top-blown steel and in finished rimmed nondeoxidized oxygen top-blown steel. Variation in total quantity and in composition of stable inclusions while metal is held in LD furnace. Effect of tapping and teeming temperatures. (Translation No. 4830)

"Chemical Heterogeneity of Large Semi-Killed Steel Ingots," by V. I. Lapitskii, K. P. Rudichev, N. I. Stupar', V. V. Oleksenko and A. I. Marinov Izvest. Vuz-Chern. Met., Dec. 1959, No. 12. Experimental work on use of bottle-top molds in conjunction with thermally insulated mold bottoms for the top pouring of tonnage carbon steels. Particulars on design and dimensions of mold bottom for 17.5 metric ton slab ingots. Optimum aluminum addition to 0.08 per cent and 0.30 per cent C rimming steels in mold to give them the structure of balanced steel. Mechanical properties and workability of balanced 0.08 and 0.30 per cent C steels compared with those of the rimmed grades. Data on distribution of carbon and sulphur in various ingots poured. Macrostructure of specimen plates and sheets. Merits of lined mold bottoms for improved chemical homogeneity and less inverse segregation in ingot bottom part. General promise of process. (Translation No. 4872)



Grefco's Radioactive Patch Still Beeps...

ONE OF MANY BRIKCAST PATCHES SHOWING UNEXPECTED PERMANENCE *(IT PERFORMED EVEN BETTER THAN WE EXPECTED!)*

• Two types of GREFCO'S BRIKCAST (Refractory Castable) were intended to fill a quick need for a temporary blast furnace patch . . .

In November, 1959, the new castables were used to reline the upper inwall and charging area of the stack in a down furnace. Radioisotopes were embedded near the wearing surface at a number of locations in the BRIKCAST to tell when erosion occurred. *Each and every isotope is still "beeping" and making its presence known to a central monitoring panel.* Monitoring deterioration of castable patches is a new technique. However, in this extraordinary installation, a continuing check has already proved the persistent quality of GREFCO castable in a severe sectional service.

But even before . . .

In August, 1959, a pneumatic-gun emplacement of the two new castables was made in a 15′-0″ hearth-diameter blast furnace. Varying thicknesses were gunned onto a large area above the mantle, restoring the lining to desired lines. This furnace has operated *more than a year* with no apparent signs of wear in the patched area.

USE BRIKCAST FOR PLANNED ECONOMY

Service records on *all* BRIKCAST installations show that BRIKCAST can be depended upon to extend furnace production life. And every time it has been used—BRIKCAST has cost considerably less than the cost of re-bricking. Not to mention the drastic cutting of downtime!

Blast furnace lining repair. Preparations complete, ready for HIGH STRENGTH BRIKCAST application with gun.

Blast furnace lining repair with HIGH STRENGTH BRIKCAST—water curing finished section.

Blast furnace lining repair. HIGH STRENGTH BRIKCAST being placed with pneumatic gun.

HERE ARE THE LATEST BRIKCAST BLAST FURNACE APPLICATIONS

NO.	HEARTH DIAMETER OF FURNACE	REPAIR LOCATION	NET TONS MATERIAL USED IN REPAIR	
			BRIKCAST-3000	HIGH STRENGTH BRIKCAST
1.	15′-0″	Starting about 5′-0″ above the mantle and extending upwards for approximately 30′-0″.	103.5	8.0
2.	17′-6″	General restoration in scattered areas from the hearth to top wear section.	2.0	23.3
3.	20′-3″	Badly damaged wear-plate area and adjacently below.		132.0
4.	21′-9″	Wear-plate area.		112.5
5.	25′-9″	Eroded areas starting at the top row of bosh-cooler plates and up to the first row of wear plates.		229.5
6.	13′-9″	From below mantle through the wear-plate section in eroded areas.	86.5	114.5
7.	27′-0″	Starting at tuyeres and extending upwards for about 12′-0″.	100.0	
8.	15′-4″	Hearth damage upwards to the mantle.	51.0	
9.	22′-0″	Eroded area from about 4′-0″ below the mantle to about 35′-0″ above the mantle.	125.0	25.0
10.	21′-0″	From C/L of tuyeres upwards for about 20′-0″.	109.5	
11.	23′-0″	From C/L of tuyeres upwards for about 35′-0″.	102.0	126.0
12.	16′-0″	From mantle up to bottom of wear plates.	212.0	32.5

TYPES, APPLICATIONS, TIME

BRIKCAST 3000—for the area from the top of the lower inwall down through the hearth and bosh.

HIGH STRENGTH BRIKCAST BLAST FURNACE MIX—for the area from the top of the lower inwall up through the wearing plates, including relining of the down comers.

Both of these specifically evolved types of BRIKCAST employ a special high purity, calcium-aluminate binder. They meet the four critical requirements: refractoriness, high strength, abrasion resistance and resistance to carbon monoxide disintegration. Both are hydraulic setting.

Without tearing out old brick BRIKCAST can be gunned into place at an average of 8000 to 10,000 pounds per hour per gunning unit. That's the equivalent of slightly better than 1000—9 inch equivalent of brick. First casts have been made within two days after job completion!

GAIN THESE ADVANTAGES:

1. The quickest return to "on blast" of a stack requiring doctoring.
2. The most economical repairing means.
3. The fullest utilization of remaining undamaged brick work.
4. Increased campaign life and the highest tonnage return on your refractory dollar.

Contact your Grefco Representative or write our General Offices and ask about Brikcast.

GENERAL REFRACTORIES COMPANY

GENERAL OFFICES: 1520 Locust Street, Philadelphia 2, Penna.

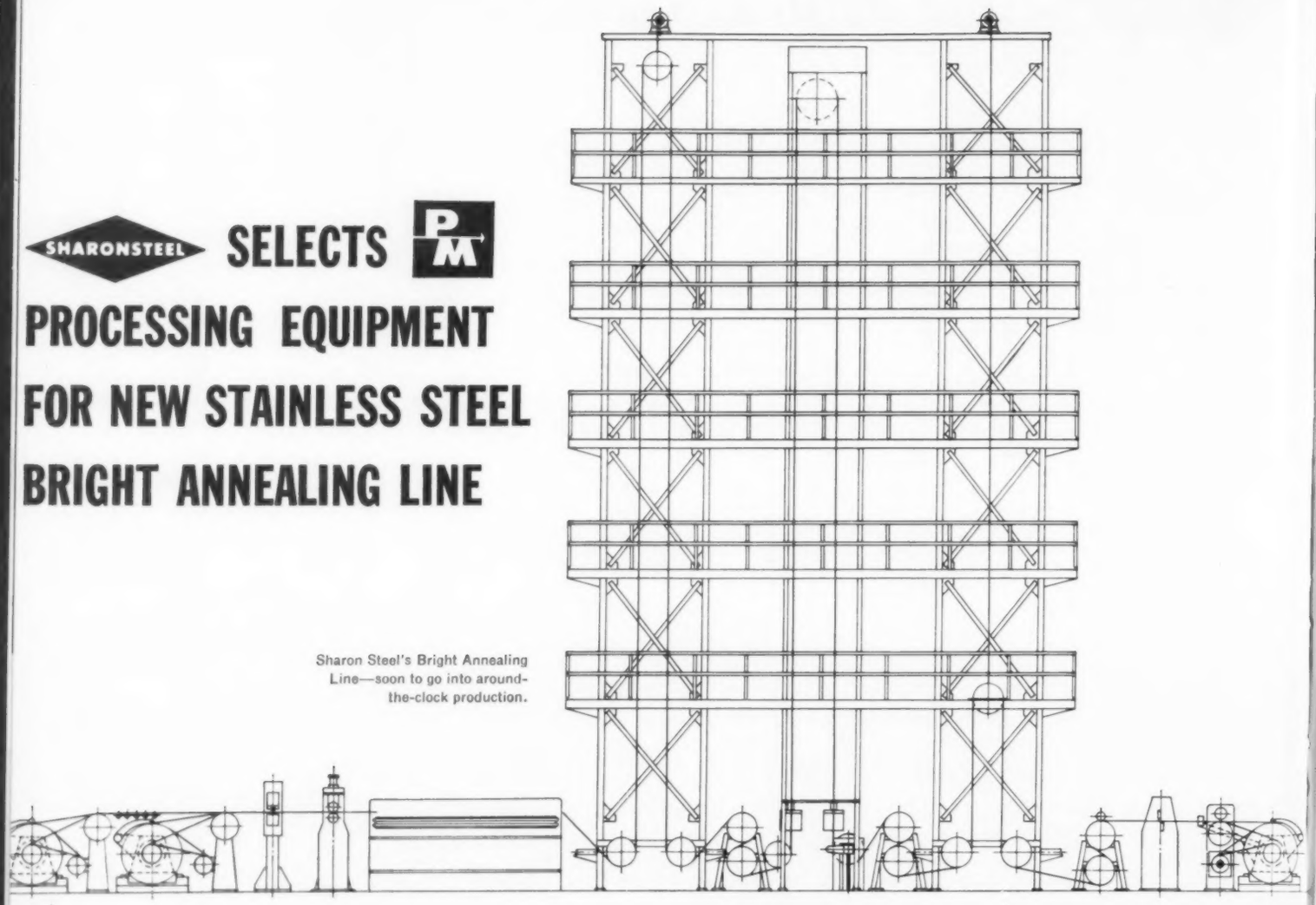
DISTRICT SALES OFFICES IN ALL PRINCIPAL CITIES

GREFCO

GENERAL REFRACTORIES

SHARONSTEEL **SELECTS** P/M

PROCESSING EQUIPMENT FOR NEW STAINLESS STEEL BRIGHT ANNEALING LINE



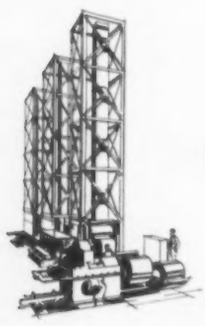
Sharon Steel's Bright Annealing Line—soon to go into around-the-clock production.

Today's most interesting development in the automotive trim market is the volume production of bright annealed stainless strip. Sharon's decision to adopt this process backs up their aim of providing a bright decorative strip that meets the most severe corrosion tests.

When Sharon Steel Corporation—one of the pioneers in stainless steel production—engineered their new, modern bright annealing line, they specified equipment designed and built by Production Machinery Corporation that will enable the line to give:

- stainless strip with a quality surface finish—protected by non-marking rolls
- continuous operation with minimum maintenance
- positive, sure strip tracking provided by 7 edge control points
- fastest coil handling and joining because of efficient, engineered equipment arrangement

Remember, P/M will design and produce what you require—the way you want it—when you need it. Let our engineers show you what "productioneered" processing lines and equipment can do to cut operating costs in your plant—build increased profits.



Production Machinery Corporation
Mentor, Ohio

Designers and Builders of Metal Processing Lines and Equipment including: lines for pickling, annealing, slitting, shearing, and cutting-to-length, grinding, scouring, coil build-up, inspection, and other sheet and strip processing lines and machinery.

P/M®

WESTINGHOUSE PRODAC BOSSES NEW 53" BLOOMING MILL

Punched cards whip through a reader . . . and the new 53" blooming and slabbing mill at U.S. Steel's South Works automatically squeezes 20-ton white-hot ingots into blooms. Bossing the complete operation: Westinghouse PRODAC* control, the first fully automatic control applied to a blooming and slabbing mill.

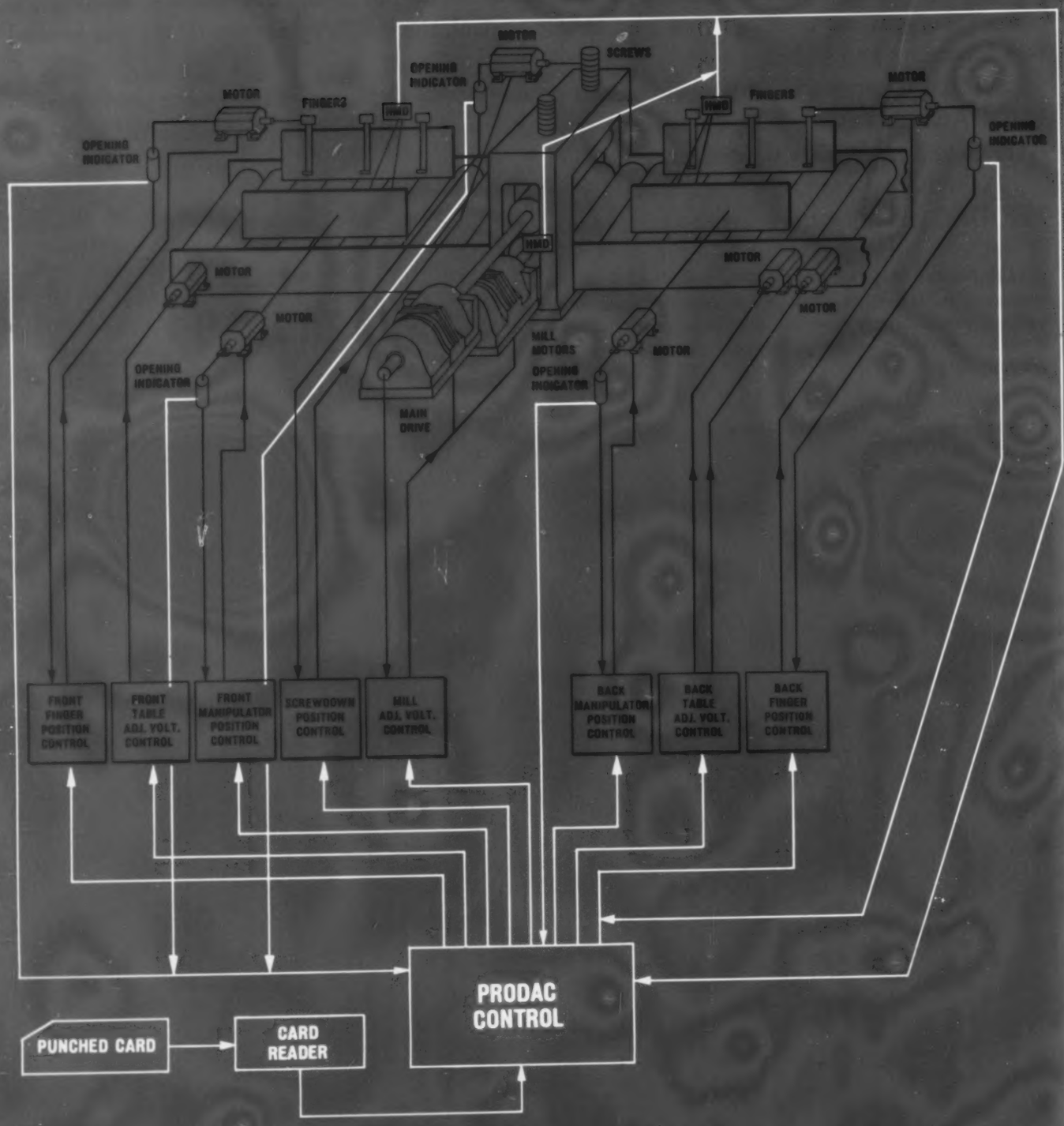
PRODAC control is one way U.S. Steel is tackling the challenge of increasing productivity. PRODAC slashes time delays between passes, utilizes full mill capacity, and eliminates human error to assure consistent, efficient operation.

Turn the page and you'll learn exactly how PRODAC goes about bossing the mill. *Trade-Mark J-96155

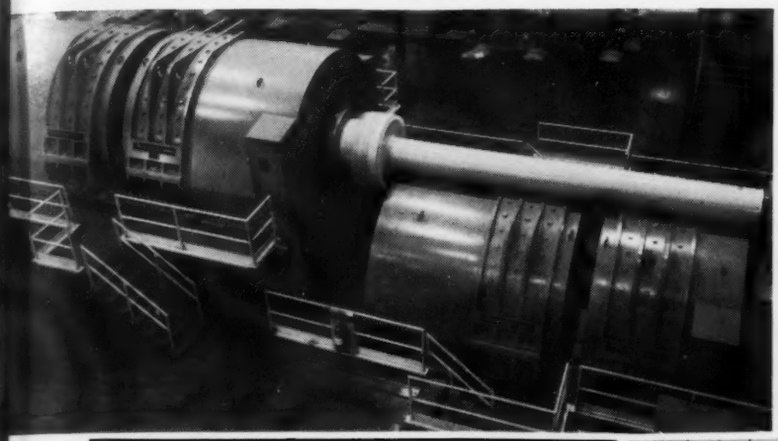
STRADDLING THE MILL TABLES is pulpit from which operator monitors mill performance. Compact desks containing unique, miniaturized controls may be operated manually if necessary. Card reader is accessible to operator for new schedules.

Westinghouse

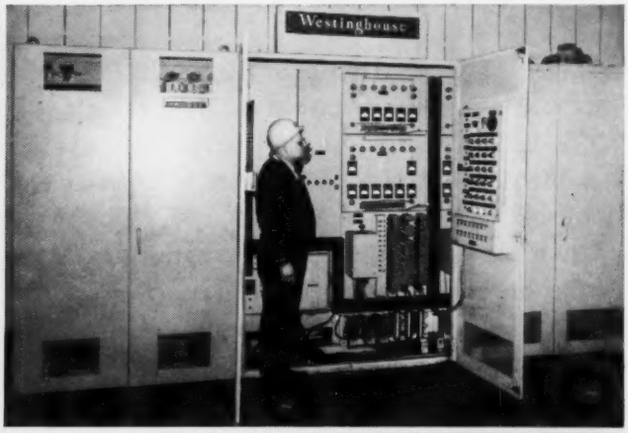
53" BLOOMING AND SLABBING MILL



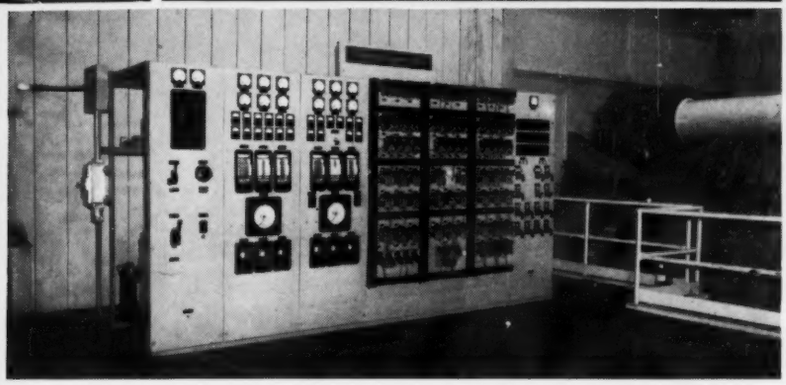
MILL MUSCLES are dependable Westinghouse motors. Here is the 12,000-hp, 40/80-rpm twin drive (foreground) with 10,000-kw flywheel m-g set.



MILL BRAIN is PRODAC control system, housed in compact cabinet, which automatically operates mill by duplicating manual actions on a predetermined sequence.



PRODAC COMMANDS ALL MILL OPERATIONS . . . EVEN INGOT TURN



THE MAIN DRIVE CONTROL features rugged steel panel construction.

PRODAC directs U.S. Steel's new blooming and slabbing mill from only three punched cards. They contain all operating information needed to execute a rolling schedule of as many as 29 passes. As shown on the diagram opposite, the cards are fed into a card reader by the operator and the data is stored in PRODAC's memory. The operator hits a button . . . PRODAC takes over.

FOR EACH PASS, PRODAC uses the proper stored data to send signals to appropriate control elements. Main drive entry speeds, acceleration and deceleration rates are precisely regulated. Screwdown openings are positioned to a final accuracy band of $\pm 1/32''$ over a 60″ opening range, while sideguards are positioned to $\pm 1/2''$ accuracy band over a 120″ range.

At PRODAC's direction, manipulator fingers turn the ingot by lifting to any of seven heights. Mill feed rolls and tables match their speed to the main drive and, on direction, adjust themselves to a present draft compensation. PRODAC control also provides for tandem rolling during early passes.

WHEN A PASS IS COMPLETED, hot metal detectors report the ingot ready for the next pass, and PRODAC sets up the mill. One schedule can be repeated for successive ingots or, for a different schedule, the operator inserts new cards and lets PRODAC carry on.

J-96155-3

Westinghouse

WHEN PRODAC SIGNALS, WESTINGHOUSE MILL DRIVES RESPOND INSTANTLY

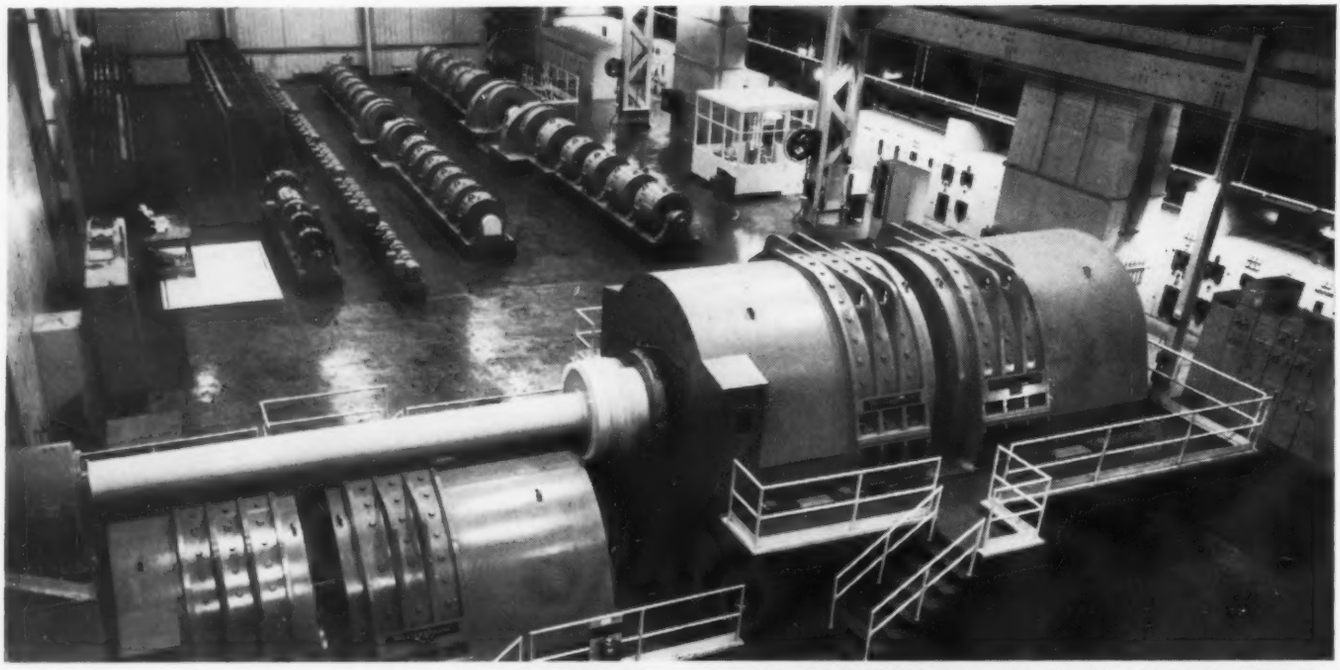
The Westinghouse drive system and related power equipment share the spotlight with PRODAC in the successful automation of U.S. Steel's blooming and slabbing mill.

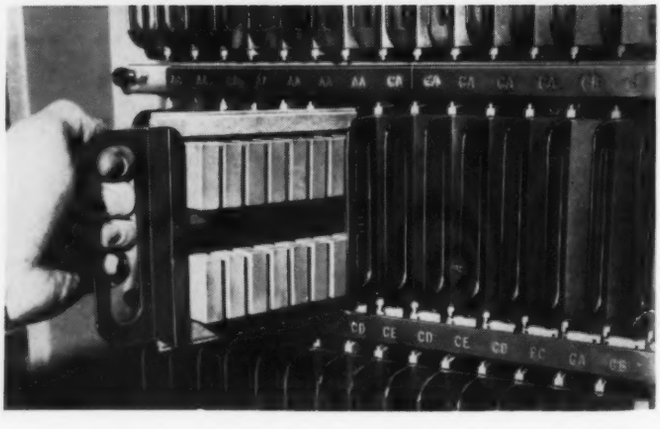
The 12,000-hp main mill drive consists of two 6000-hp double armature twin motors. The screwdown, manipulators, fingers, and front and back table and feed rolls each have Westinghouse adjustable voltage drives complete with Magamp regulators. Complete engineering and coordination of these drives assure the instantaneous response to PRODAC's commands critical to keeping the mill on schedule.

PRODAC control like that for U.S. Steel is a key element in Westinghouse *Progressive Automation*. This new concept aims at helping steel producers boost product quality and quantity through economical, step-by-step automation. Your Westinghouse representative has details on *Progressive Automation* . . . and PRODAC. Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. *You can be sure . . . if it's Westinghouse.* J-96155-1-4

Westinghouse

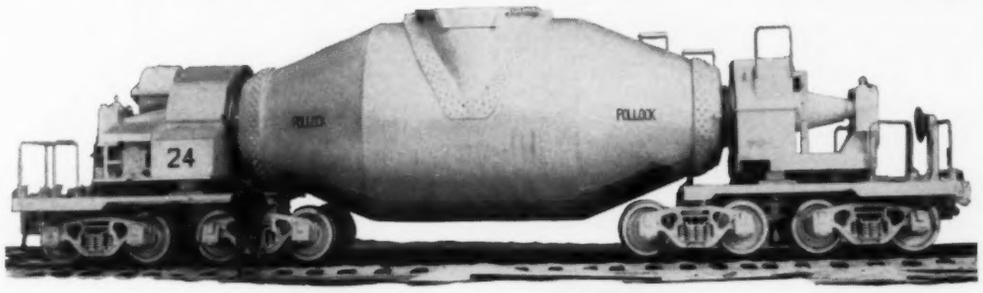
12,000-HP MAIN MILL DRIVE (foreground) with auxiliary m-g sets and exciters (upper). **THE FIRST ALL-STEEL PANEL** construction is utilized in this variable voltage auxiliary control (lower left). **SINCE THE INSTALLATION** of the mill, the PRODAC module, representing a circuit function, has been refined. The new module is shown below and is easily accessible for removal or replacement (lower right).

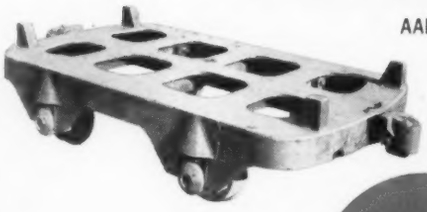




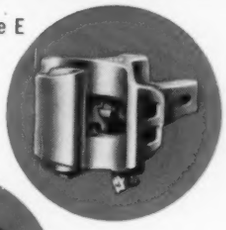
CAR PROTECTION !

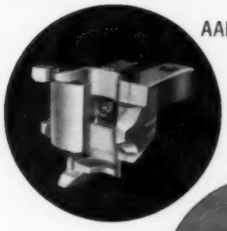
There's a National combination of Coupler and High Capacity Rubber Draft Gear to fit your car and its protection needs. Increase car availability, reduce maintenance time and cost.



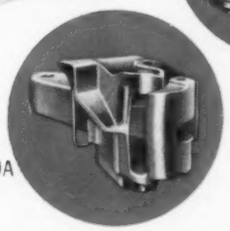


AAR Type E



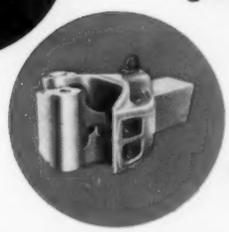


AAR Type F

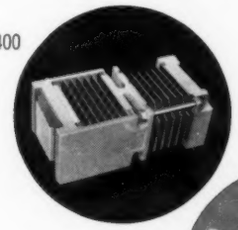


Sharon-10A

NATIONAL
COUPLERS

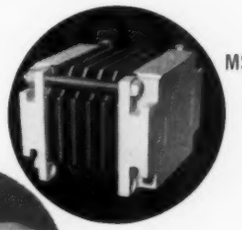


National AP

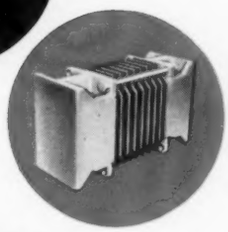


MF-400

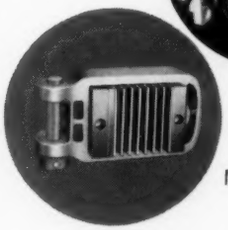
NATIONAL RUBBER
DRAFT GEARS



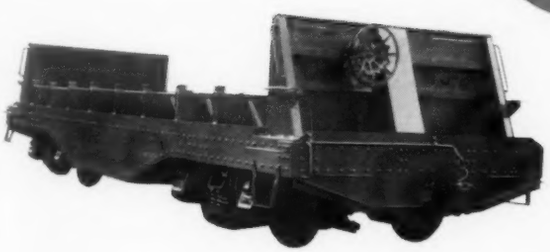
MS-485-6A

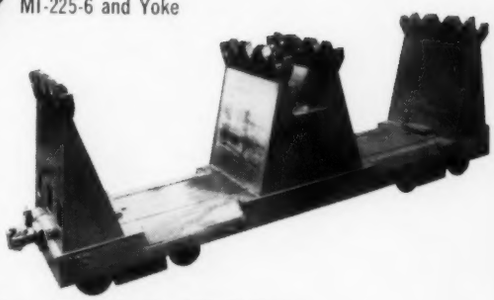


MF-491-A



MI-225-6 and Yoke



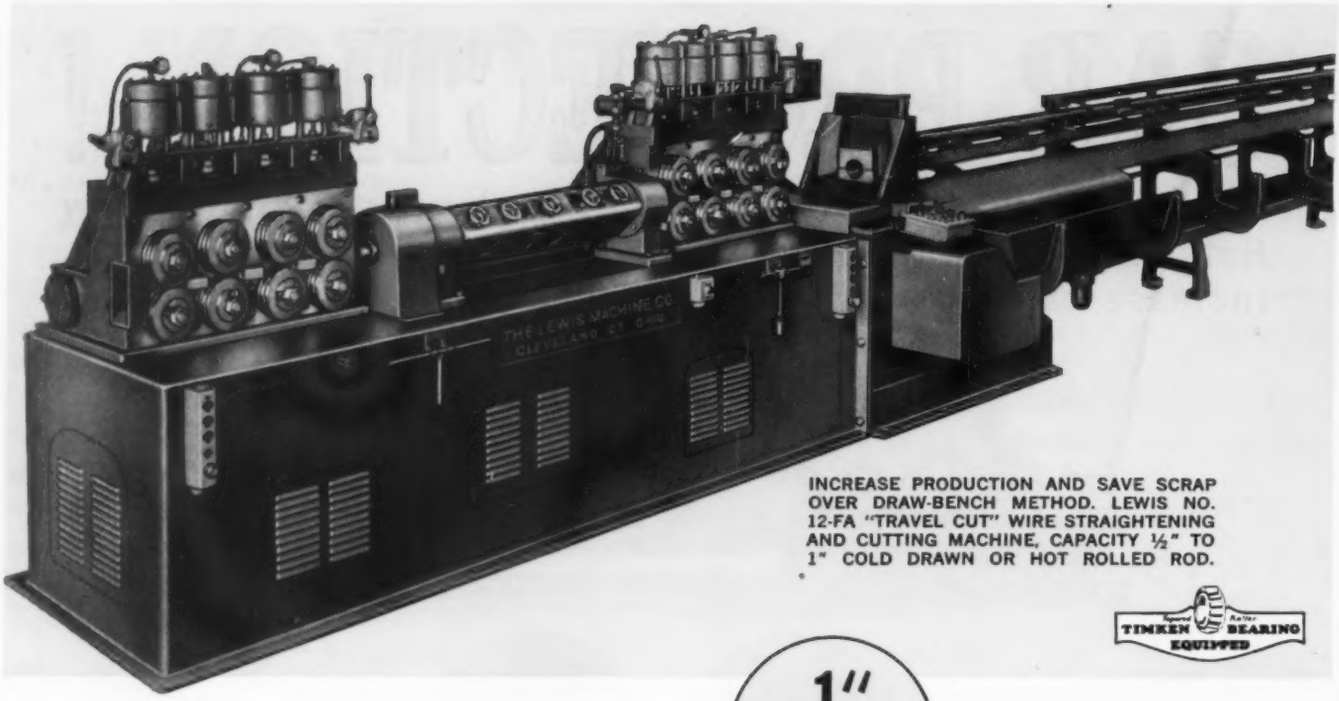


Transportation Products Division

Type E coupler and MF-400 gear assembly

NATIONAL
MALLEABLE AND STEEL
CASTINGS
COMPANY

Cleveland 6, Ohio



INCREASE PRODUCTION AND SAVE SCRAP OVER DRAW-BENCH METHOD. LEWIS NO. 12-FA "TRAVEL CUT" WIRE STRAIGHTENING AND CUTTING MACHINE, CAPACITY ½" TO 1" COLD DRAWN OR HOT ROLLED ROD.

TIMKEN BEARING EQUIPPED

Now...straighten and cut 1" dia. rod FROM COILS at speeds up to 350 fpm.

HERE'S WHY IT CAN BE DONE

CUT-OFF Flying Shear Type. Pure crank motion for both cutting and traveling permitting high speeds with minimum shock.

ROTARY ARBOR Two-speed with dual-center straightening dies for faster, more accurate straightening over a wide range.

ROLL HOUSINGS Dual-range pushbutton operated pneumatic feed pressure for exact feed control and coil end pull-through without twisting.

LENGTH GAUGING Light pressure on electric trip switch actuates air clutch. Wire is gauged and released with positive moving mechanism . . . springs and latches have been eliminated.

TRANSMISSION Positive sliding-gear type with eight feed speeds — 115 to 350 FPM.

Write for Brochure. Other models available to handle rounds from .012" to 1" dia. Shapes from 1/16 to 5/8" square, hex and flats.

THE LEWIS MACHINE COMPANY
A DIVISION OF CURTIS MFG. CO.
3441 EAST 76TH STREET • CLEVELAND 27, OHIO

VICTOR R. BROWNING

Mill Type Cranes

TO SPECIFICATION...

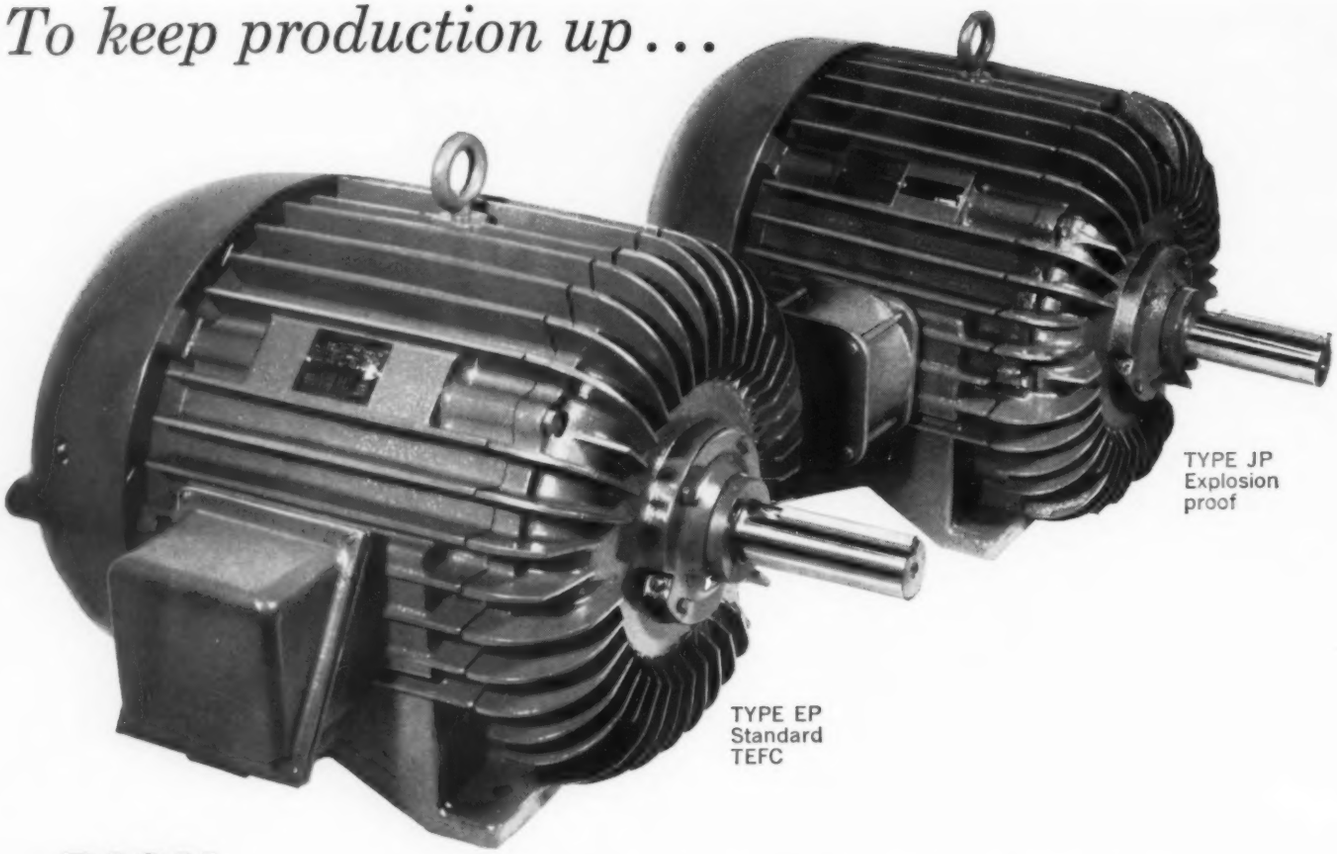
Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.

WILLOUGHBY (CLEVELAND), OHIO

DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES

To keep production up . . .



PICK FROM THIS PROTECTED PAIR...

Here's a power-packed pair of Wagner® totally-enclosed fan-cooled motors —Type EP, standard, protected against damage from dust, abrasive, fumes, steel chips or filings; and Type JP, explosion-proof, for safe use in specified hazardous locations.

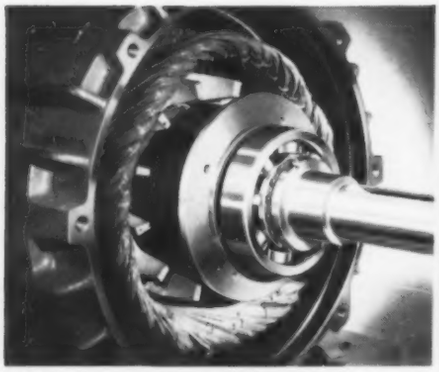
They'll keep your production rates up, delivering full rated horsepower under the toughest conditions . . . staying on the job with dependable, continuous service that means peak output. They're the perfect pick, for individual machines or for automated lines.

In the design illustrated, these motors are built in ratings through 100 hp in NEMA frame sizes 182-445U. Let your Wagner Sales Engineer show you how this protected pair (or larger Wagner enclosed motors through 500 hp) gets the job done. Call him, or write us for Bulletin MU-224.

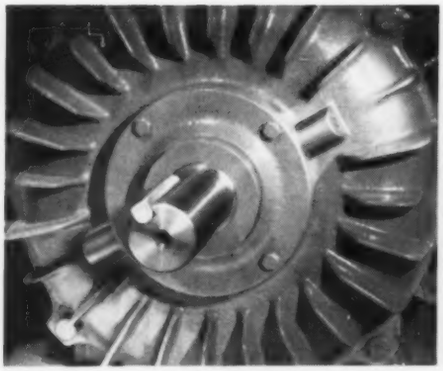
Wagner Electric Corporation

6483 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

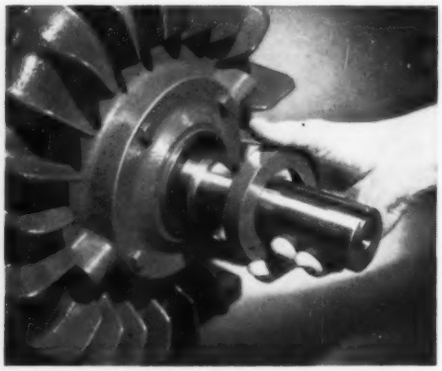
WM60-19



HEAVY-DUTY BALL BEARINGS . . . The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long, troublefree service under heavy loads.



BEARINGS CAN BE RELUBRICATED . . . Factory lubrication will last for many years under normal service, but openings are provided to permit relubrication that adds years to motor life under severe conditions.



SECURELY SEALED FOR LOW MAINTENANCE . . . Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

Predictable Performance

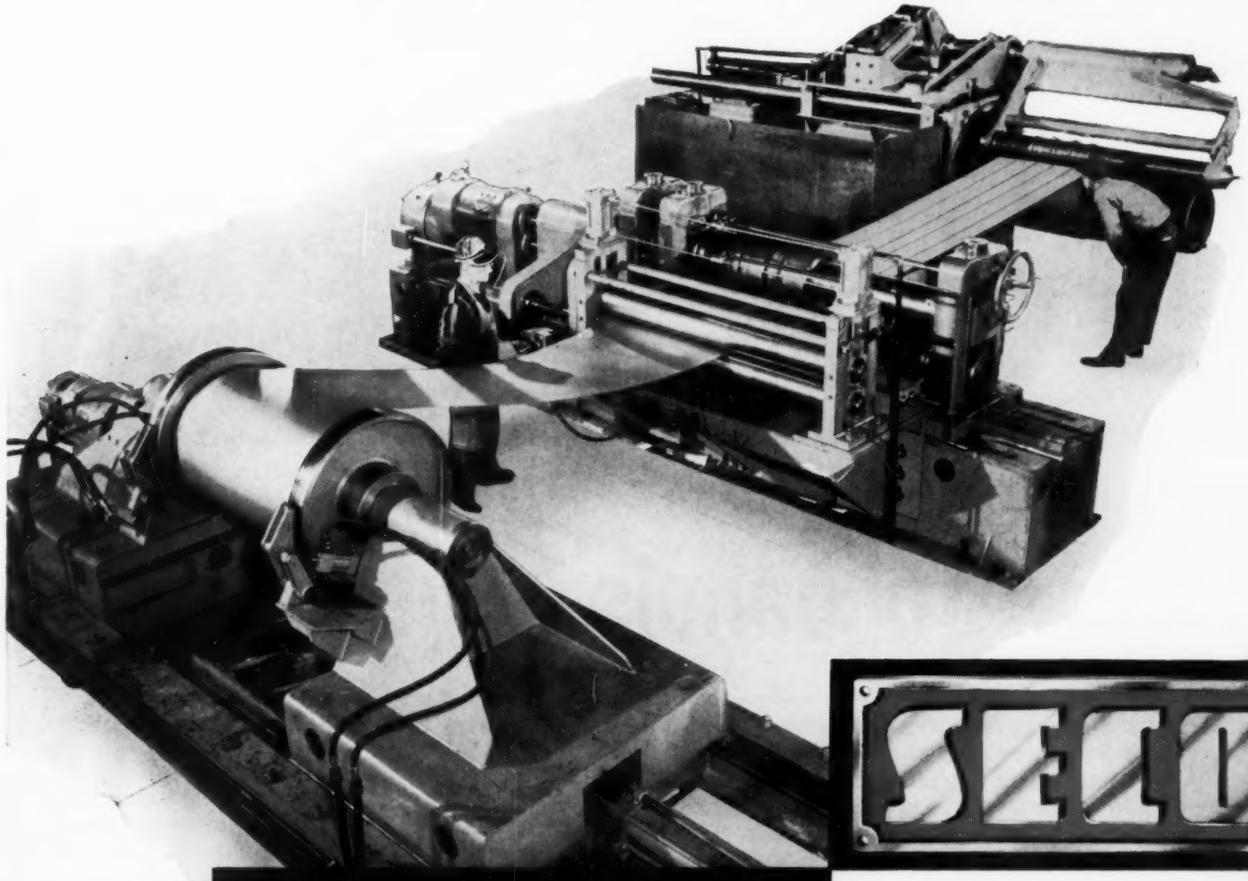
...is assured
Detroit Steel Corporation
with the installation of a

SECO **60" SLITTING LINE**

Availing themselves of SECO's facilities for custom building efficient slitting lines, the Detroit Steel Corporation, Detroit, Michigan, just recently installed this 60" Seco Slitting Line thereby assuring predictable performance. The entire unit, consisting of a cone-type Uncoiler, Slitter and Recoiler, was specifically designed and built by SECO for this customer.

Whatever your present requirements may be, call upon SECO's staff of trained sales engineers to assist you in planning for the present as well as your 'future' capacity.

Seco builds a complete range of slitting lines available from 12" to maximum strip widths.



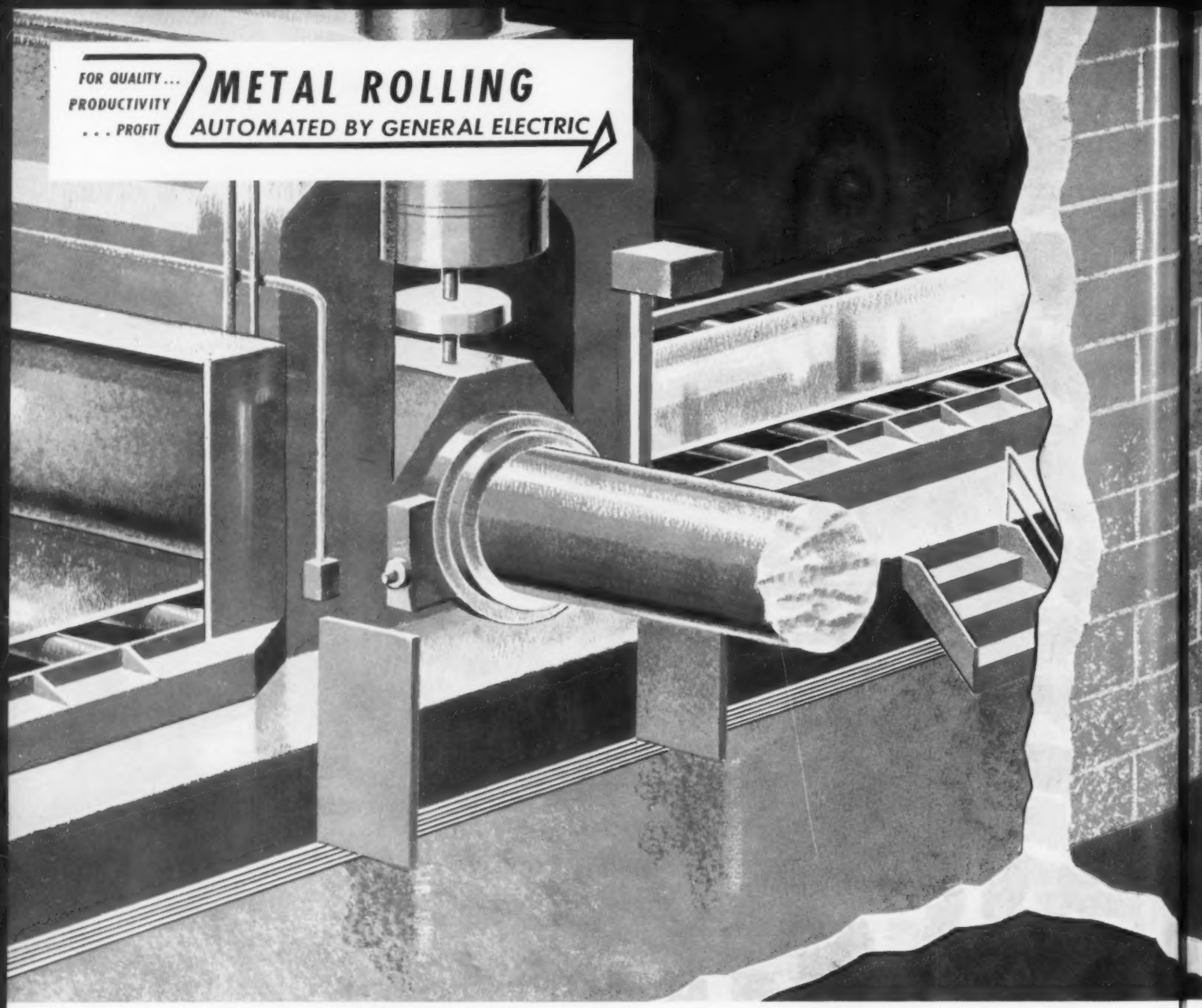
STEEL EQUIPMENT COMPANY

P. O. BOX 737, WARRENSVILLE STATION
CLEVELAND 22, OHIO

SECO STEEL MILL EQUIPMENT

- Leveling and Shearing Lines
- Combination Edging and Flattening Lines
- Tension Reels for Strip Polishers
- Narrow Strip Grinding Machines
- Slitting Lines
- Multiple Strand Pull-out Rolls and Take-up Frames
- Strip Coilers (Up and Down Type)
- Traverse Reels for Narrow Strip
- Steel Coil Up-enders
- Scrap Ballers

Affiliated with Lee Wilson Engineering Co., Inc.



GENERAL ELECTRIC CONTROL FOR STEEL MILLS

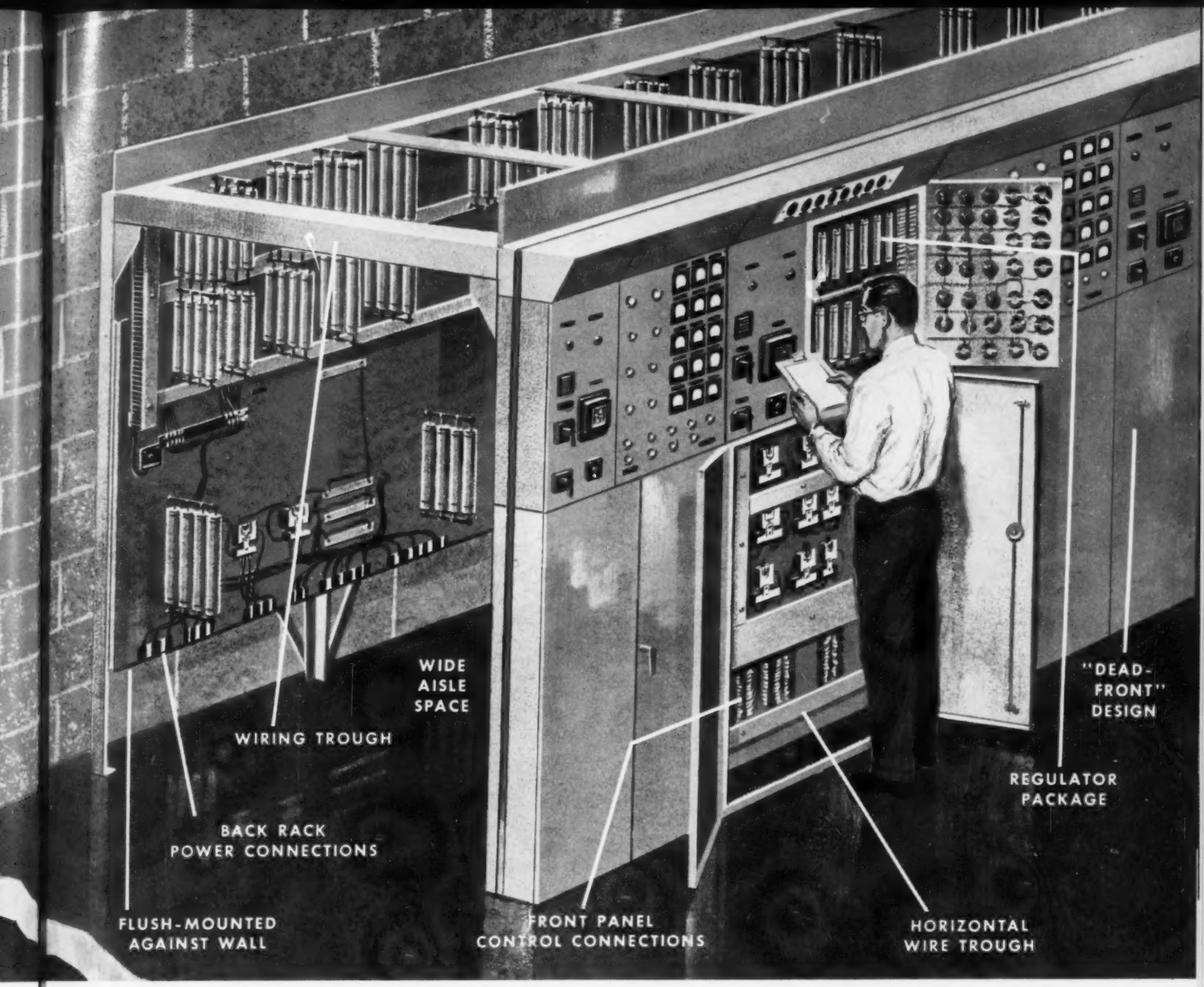
New control panels cut connection

General Electric has redesigned its industry-proved, heavy-duty, steel mill control panels—adding features to permit greater utilization of mill space . . . to save you time and money in installation and maintenance . . . and increase safety for operating personnel. The following cost-cutting and work-saving benefits tell the story of these new panels:

Reduced floor space—Compact design of this new panel cuts floor space needs up to 35 percent. More efficient arrangement of components provides added room for work inside the panel, yet reduces panel length. All incoming wires for control terminate at the front of the panel. All power wiring, including customer power connections, is isolated on the back rack. Use of welded studs and cage nuts permits installation against a wall —no need for additional work space behind panel. This saving in space means that valuable floor area can be used for other purposes, or construction costs of new buildings can be reduced.

Easier field connections—Installation wiring time is reduced as much as 50 percent by improved wiring layout. All incoming control wiring is brought to the front of the panel. A horizontal wire trough is available to the contractor to facilitate wiring to proper terminals and eliminate cord-tying bundles of wires in the field. Doors on the front of the panel open for access to terminal boards. For quick identification, terminal designations are permanently ingrained on the terminal board and into high-quality, plastic sleeves on each wire end.

Simplifed maintenance—Wide aisle between front panel and back rack makes maintenance easier and safer. Devices on front panel and back rack are connected *from the maintenance aisle,* allowing work from only



time 50%, required floor space 35%

one location. On the regulator package, fine-tuning adjustments are easier since potentiometers are located next to their related meters.

Increased safety—Since power wiring and all field power connections are isolated on the back rack, operating personnel are protected from accidental contact with high voltage. "Dead-front" construction, utilizing regulator packages and front panel devices behind doors, affords additional protection.

Improved appearance—All-steel bases provide rugged construction and uniform panel shape. Packaging of equipment into functional components and placement of contactors and relays behind doors give straight-line, modern appearance to panels.

For details on these steel-mill control panels, see your G-E Sales Engineer. Or write Sect. 785-13, General Electric Co., Schenectady, N. Y. for Bulletin GEA-6701. *Industry Control Dept., Salem, Va.*

Progress Is Our Most Important Product

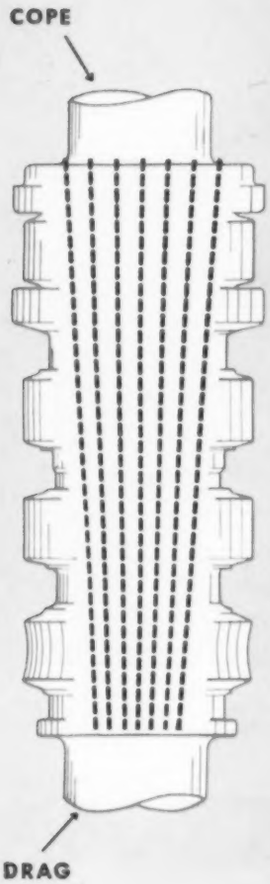
GENERAL ELECTRIC

TIPS FROM A ROLL MAKER'S NOTEBOOK

MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania

Cast mill rolls • Johnston cinder pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings

With rolls, it pays to know which end is "up"



Cast steel structural mill roll shows good pass location to promote proper directional solidification.

There's a very good reason why every roll shipped by Mack-Hemp carries the word "DRAG" engraved on one wabbler. With all cast rolls, maximum strength and depth of sound metal tend to occur toward the *drag* end of the roll—the end at the bottom of the mold when the roll is being poured. This is because of the normal manner in which the "lines of solidification" form as the molten metal cools and solidifies. Also the pressure from the weight of the metal above helps increase the density of the metal in the drag end of the roll.

As you can see from the diagram at the left, the solidification lines angle gently outward as they rise toward the top or "cope" neck of the roll, forming a cone-shaped pattern. In general, these lines of solidification mark the boundary of the dense, homogeneous metal. As a result, there is more good metal in and near the drag end than at the cope end. To assist the roll user in quickly identifying the "bottom" end of his rolls, Mack-Hemp brands the drag wabbler of every roll produced in its foundries.

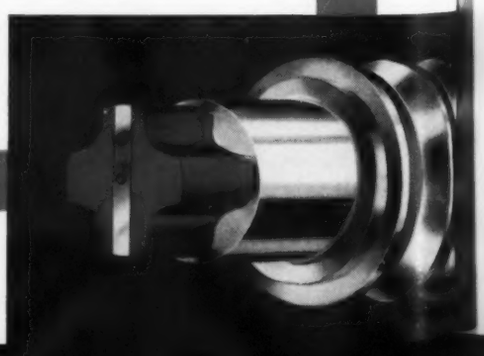
Locate the deepest passes in the DRAG end—Roll designers making drawings for blooming, rail and structural mill rolls should try to locate the deepest passes in the driven end of the roll, as illustrated. Directional solidification from drag to cope is then more easily accomplished and a sounder casting results.

We don't mean to imply that deep passes cannot be located at the cope end of the roll—in some instances, the overall mill layout, flow to the next mill, etc. may make it necessary to have the deepest pass in the cope end. When possible, however, this should be avoided since a deep pass in the cope end of the roll will restrict proper feeding of the lower portion of the roll.

Another factor—For maximum roll life, roll blueprints should call for the deepest passes at the driven end of the roll body. If you have a special reason why they must be located elsewhere, note it on the drawing; otherwise any roll maker worth his salt will ask you about it.

Another good rule to follow is to check with Mack-Hemp on any problem of roll selection or application. In a century and a quarter of making mill rolls, we have run across just about every conceivable situation involving the use of rolls. Our advice is yours for the asking. Feel free to telephone or write us at any time.

An important legend... for maximum roll life, the drag wabbler should be driven.

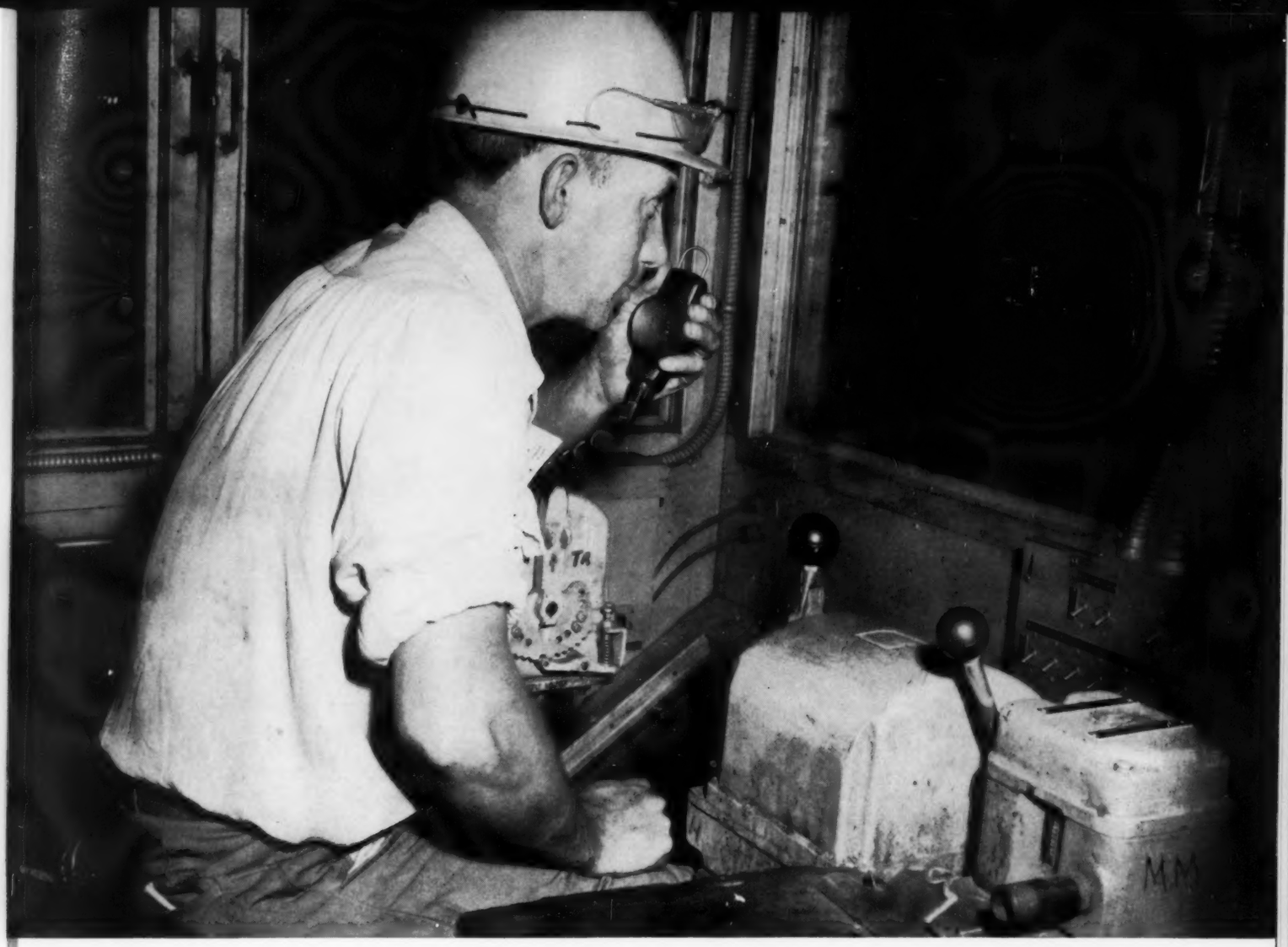


MACKINTOSH-HEMPHILL

You get more tonnage from the rolls with the Striped Red Wabblers

Division of E. W. BLISS COMPANY

Presses, Rolling Mills, Special Machinery



Ray Townsend's crane and 1,000* more are equipped with Femco Trolleyphones

Ray operates a soaking pit crane in the plant of Lukens Steel Company in Coatesville, Pa. You will find the thousand other Trolleyphone users in almost every steel producing plant in the United States and Canada—not to mention plants in Australia, Brazil, Germany, India, Italy and other countries.

We admit that one reason for this widespread use of Trolleyphones is that Femco was first in the field with an FM carrier communication system operating over in-use power lines or collector rails. Mills were quick to appreciate the added safety and efficiency which Trolleyphones provide, but the reason that Femco Trolleyphones have kept their lead is that for 15 years they have provided clear communication under all conditions, with equipment that is compact, rugged, dependable, easy to install and easy to maintain.

That's why mills turn to Femco, not only for communication systems but also for systems of automatic and remote control for a wide variety of plant operations. Many of these systems are individually engineered for specific applications, and we invite your inquiry concerning any problem in these fields.

* Estimate based on total Trolleyphone sales to steel mills. Mills buy Trolleyphones for cranes, ingot buggies, locomotives, coke pushers, door machines and other equipment, so we can't keep track of the intended use of every unit.

Femco
INCORPORATED
IRWIN, PA.

COMMUNICATIONS: Carrier and wired audio systems for all mining and industrial applications. **MONITORING:** Fans, circuit breakers, valves, pumps, compressors, etc. **TELEMETERING:** Flows, pressures and other functions. **REMOTE CONTROL:** Pumps, valves, circuit breakers; soaking pit covers, furnace doors; cranes, or other moving equipment.

MAJOR REASONS FOR SPECIFYING NATIONAL ELECTRODES...

TRADE MARK

QUALITY · SERVICE · DELIVERY FACILITIES

RESEARCH & DEVELOPMENT

PLANTS

NATIONAL CARBON has electrode-producing facilities unsurpassed the world over!

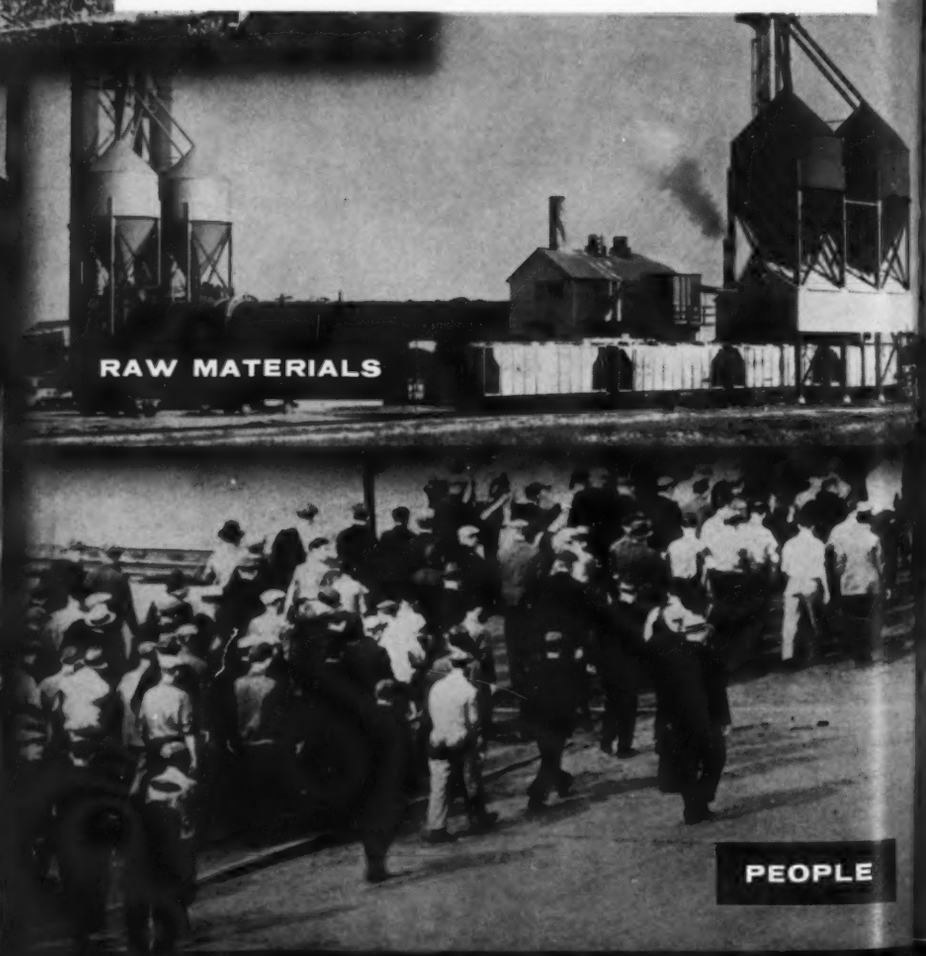
When you specify "National" electrodes you can be sure that National Carbon Company has the facilities — or to state it another way, the combination of ingredients — to provide you with a quality product for use when you want it. What are these ingredients?

In addition to abundant supplies of raw materials, NATIONAL CARBON plants are staffed with personnel thoroughly experienced in electrode production techniques. They have at their disposal the latest equipment available to help them produce quality products that are unsurpassed in the industry today. This combination of raw materials, experienced personnel and modern equipment is backed by extensive research and development programs, which means NATIONAL CARBON can supply your every electrode need . . . no matter how large or small. For details, contact National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, New York. In Canada: Union Carbide Canada Limited, Toronto.

"National" and "Union Carbide" are registered trade-marks for products of

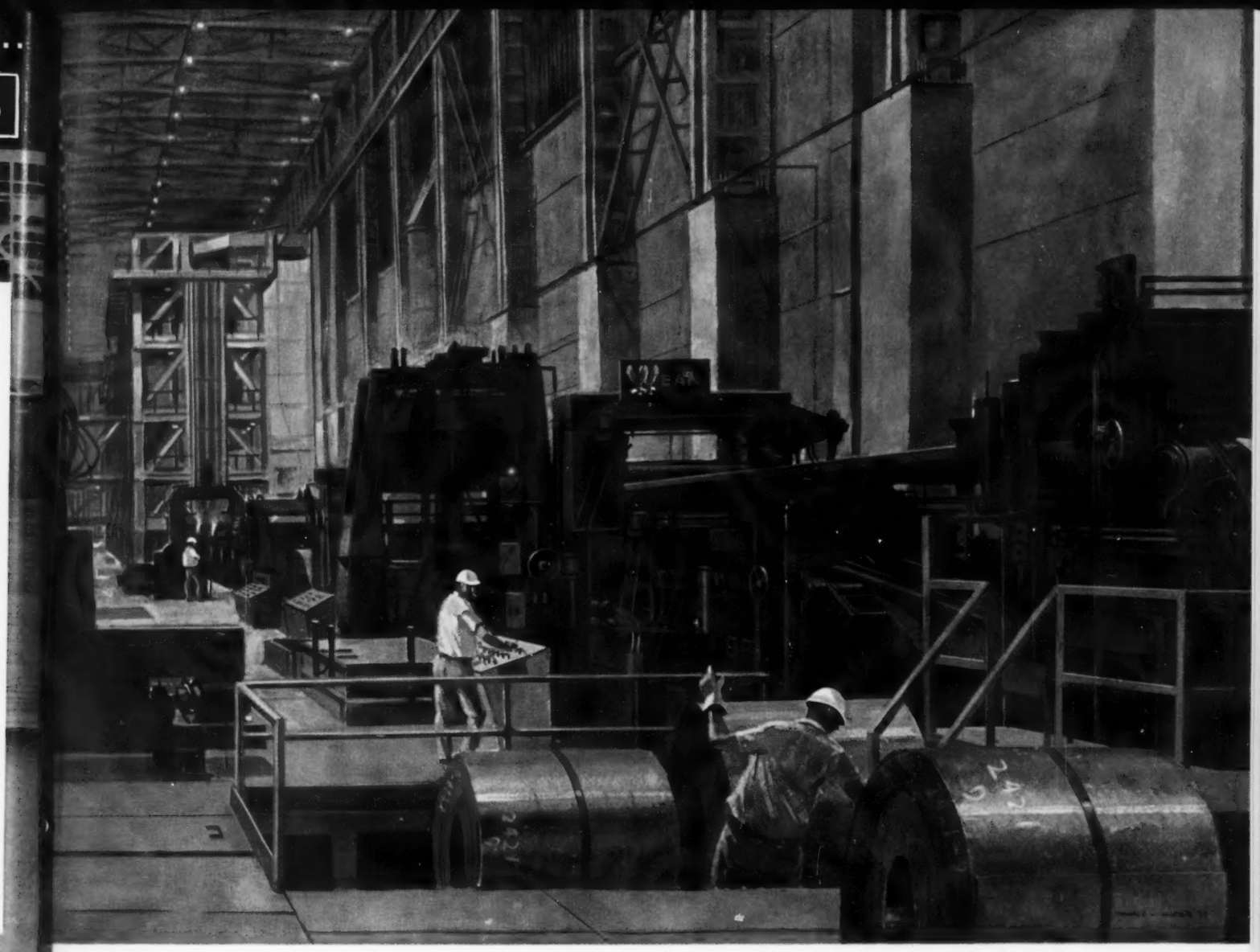
NATIONAL CARBON COMPANY UNION CARBIDE

EQUIPMENT



RAW MATERIALS

PEOPLE



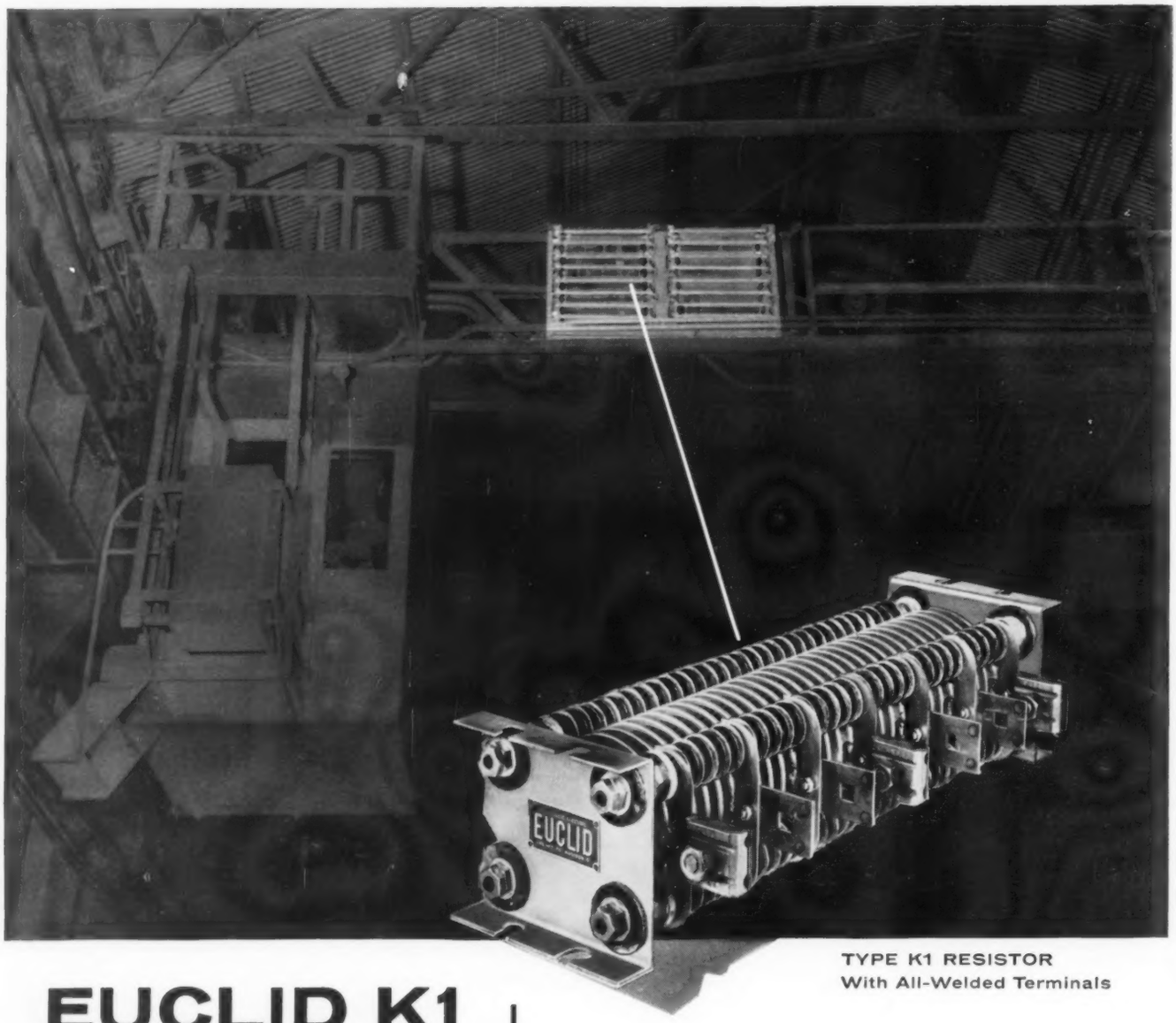
Entry end of No. 4 continuous galvanizing line, Weirton Plant, Weirton Steel Company

Wean, Weirton and Galvanizing . . .

Weirton Steel Company, Division of National Steel Corporation, added this continuous hot-dip galvanizing line to meet the demand by customers for fine quality zinc-coated sheet. This line was specifically designed to process heavy gauge strip in widths up to 50″, extending Weirton's coverage of finished sizes.

The Weirton line handles 65,000 pound coils and provides for either recoiling or shearing operations at the exit end. Shear lengths vary from 48″ to 192″. A horizontal cleaning section provides superior cleaning of the strip. Six bridles maintain continuous tension regulation throughout the line, permitting a wider range of gauges. Weirton's new galvanizing line is an example of Wean's *creative engineering*, oriented to solving a company's expansion needs. Why not take advantage of Wean's years of experience in your planning to meet expanding demand for galvanized products.

THE WEAN ENGINEERING COMPANY, INC. • WARREN • OHIO



TYPE K1 RESISTOR
With All-Welded Terminals

EUCLID K1 Heavy-duty Resistors

Installation on Steel Mill Crane

Specify **EUCLID** Type **K1** King-Size Resistors
the next time you have a resistor burnout!
(38 to 200 amperes capacity based on 375°C rise)

Please contact your nearest EUCLID Representative

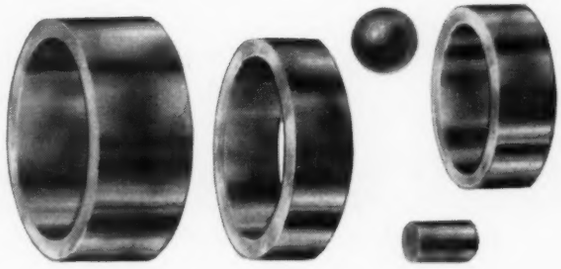
WHAT'S YOUR PROBLEM?
Ask for Bulletin 3004

The EUCLID Electric & Mfg. Co.
Dept. A • MADISON • OHIO

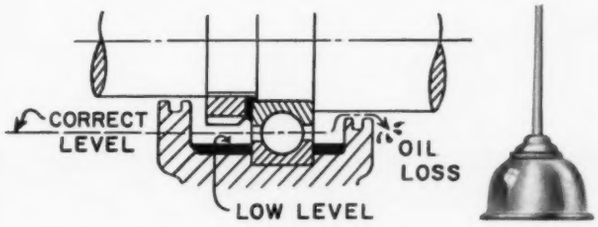
DISTRIBUTOR DAN, the SKF bearing man, tells

WHY BEARINGS BECOME OVERHEATED

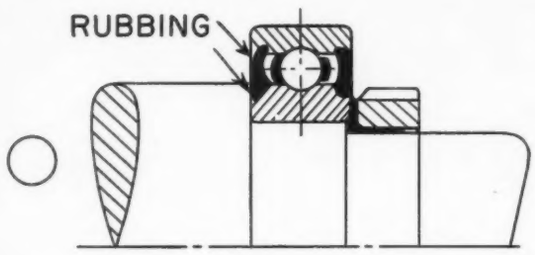
and how to correct the conditions that cause excessive heat.



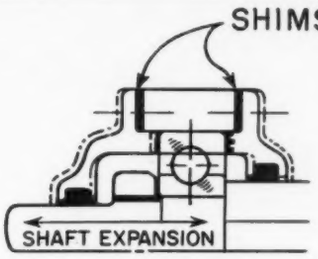
LOOK FOR THIS SYMPTOM. Discoloration of a bearing's rings, balls or rollers is a sure sign of overheating. The color is usually a gun-metal blue or bluish black.



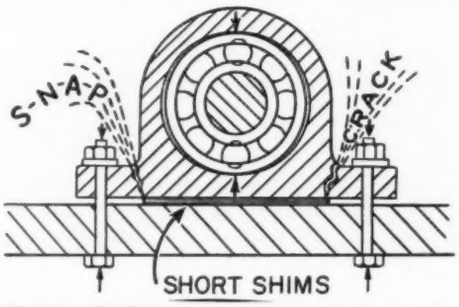
IMPROPER LUBRICATION OR LUBRICANT accounts for most cases of overheating. In pillow blocks, if oil is specified, fill only to the center of the lowest ball or roller in the bearing. If it's grease, the lower half of the pillow block should be filled. Therefore, be sure you're using the right lubricant—**in the proper quantity.**



RUBBING is a frequent culprit. Check the running clearance of the bearing seal. If it rubs against the shaft shoulder, re-machine the shoulder, to allow proper clearance. Bent lock-washer prongs are sometimes to blame. Straighten them or replace the washer.



EXTERNAL HEAT, conducted through the shaft, can make an inner ring expand excessively. It's usually the result of using a bearing with inadequate internal clearance. Make sure the replacement bearing is exactly the same as the original bearing. Should the markings be indistinct, consult an **Authorized SKF Distributor.**



THE BEARING HOUSING may be to blame—if it's warped or if the bore is distorted and out-of-round. Check to see whether the bore is pinching the bearing and relieve by scraping the bore. Make sure, too, that the pedestal surface is flat and that any shims cover the entire base area.

Baffled by a bearing problem? Whether it's selection, mounting, or maintenance—consult your Authorized SKF Distributor. He's staffed to help you keep them running smoothly and he stocks all the bearing types and sizes you need.

SKF

AUTHORIZED DISTRIBUTOR

6010

Spherical, Cylindrical, Ball, Tyson Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

® REG. U. S. PAT. OFF.

Another *plus* of Lightweight B&W Insulating Firebrick

LOWER DENSITY means

DENSITY IN LB/9" EQUIVALENT

B&W K-23 Insulating Firebrick · 1.85 lb/9" equiv.

Competitive Insulating Firebrick · 2.66 lb/9" equiv.

NOTE: The above chart, based on available published figures, shows the appreciable difference in weight between low density B&W IFB and the average of eight other leading insulating firebrick with a 2300 F use limit. Similar savings in weight are offered by B&W IFB at all temperature levels.

All insulating firebrick are not the same. Published figures show wide variations in *all* of the important properties among the leading brands of IFB.

Take density. This important property, related to the porosity and the light weight of the brick, affects furnace weight, construction costs, fuel costs, and temperature control. Densities range from a B&W Insulating Firebrick low of 1.85 to a high of 2.80 per 9 inch brick for a competitive Insulating Firebrick—*approximately a 35% difference in dead weight and insulating efficiency.*

You are paying for *insulating* firebrick . . . make sure you get *all* the benefits. B&W—the originator of IFB—manufactures a full line of IFB with an experience-proved balance of light weight, high insulating value, high strength and long life.

For complete information on B&W Insulating Firebrick, write for Catalog R-2-H to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

NUMBER 2 OF A SERIES

LESS FURNACE WEIGHT

the payoff

9 TONS LESS WEIGHT to heat and lift in this hood-type, 8 stack annealing furnace. Lined with B&W IFB at 1.85 lb per 9" straight, the refractory lining of this furnace weighs 37,000 lb as compared to 55,200 lb for *average weight competitive IFB*. 33% less weight to heat and lift when you specify B&W IFB. This is just one of many proofs in our files that "there is an important difference in insulating firebrick."

B&W

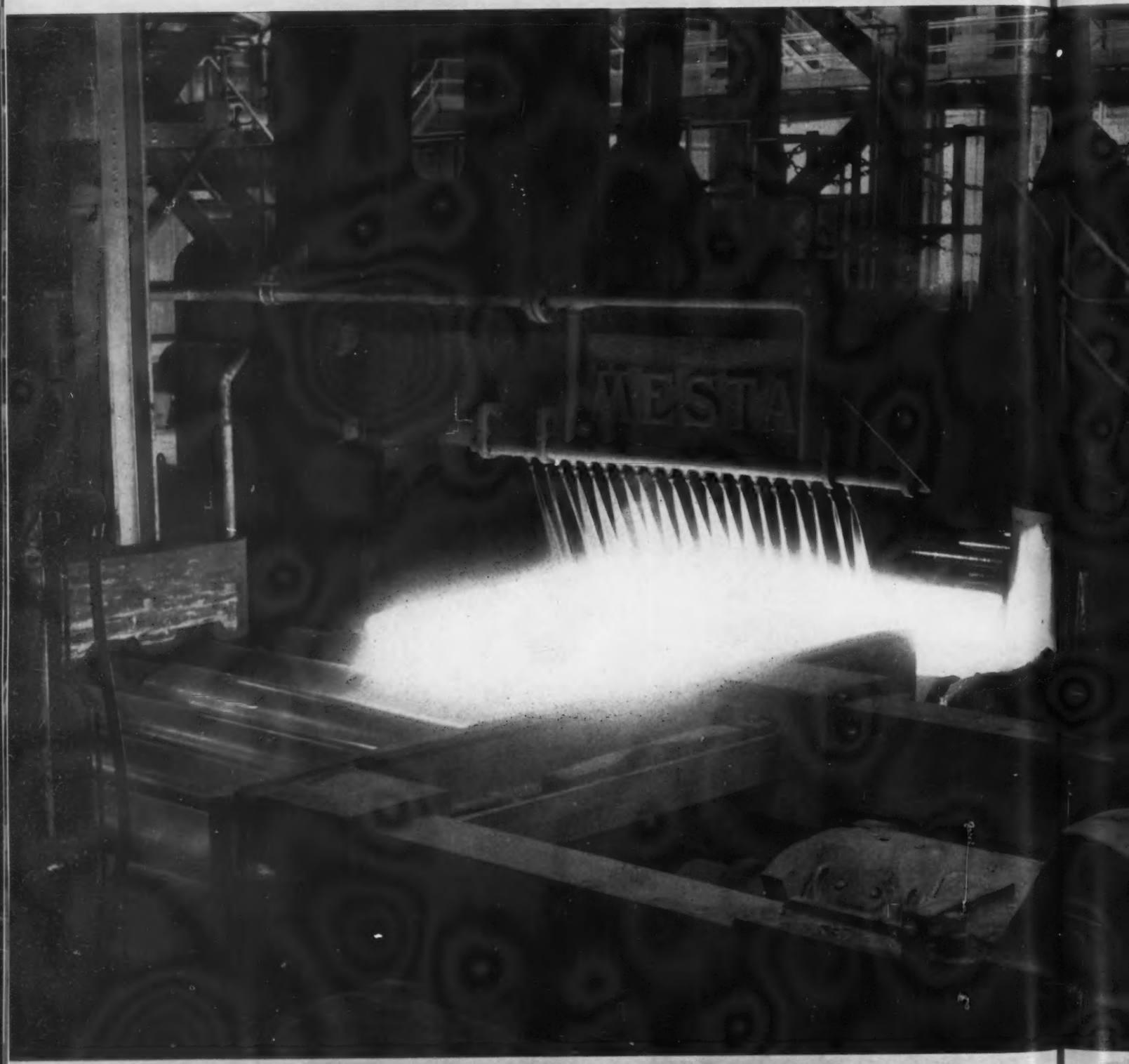
THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

R-859

DE LAVAL
CENTRIFUGAL PUMPS

for high-pressure de

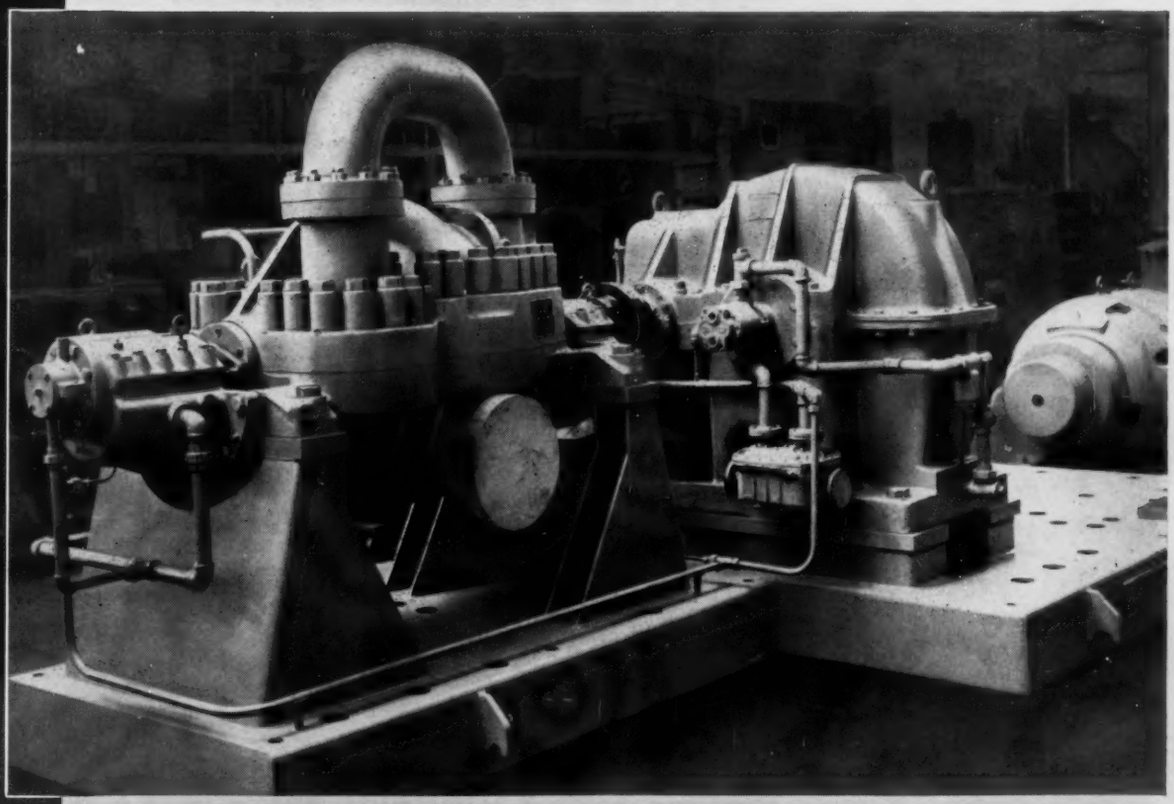


descaling at Lukens Steel

Latest successful technique of high-pressure descaling is now being performed in this modern steelmaking facility designed by Mesta Machine Co.

The initial high-pressure descaling operation uses De Laval split-case multi-stage pumps as shown in the photograph below. Each pump supplies cold water at 1000 gpm and 1600 psig. Electric motors rated at 1750 hp drive the pumps through speed increasers which raise the speed from 1200 rpm to 4250 rpm.

De Laval pumps also serve Lukens on a 1200 psig descaling system in another section of the Coatesville, Pa. mill.



One of several arrangements available for descaling service at pressures of 1000-1200-1600 psig and capacities to 2200 gpm.

DE LAVAL *Steam Turbine Company*

870 NOTTINGHAM WAY, TRENTON 2, NEW JERSEY

DL470

MORE THAN 5,000,000 TONS OF STEEL WITHOUT A BEARING FAILURE

The Torrington Company, Bantam Bearings Division, South Bend, Indiana, is especially noted for the high quality of its rolling mill bearings. Usage of modified AISI 3310 USS CARILLOY Steel in races enables Torrington to manufacture quality bearings with a foot-pound energy absorption rate of a magnitude impossible to obtain with any other conventional alloy steel. Translated into performance, rolling mills equipped with these bearings have produced more than 5,000,000 tons of steel without a bearing failure!

Before using the modified USS Alloy grade, Torrington tried several different types of steel which gave considerably lower tonnages before failure occurred. Then with the application of the 4% nickel alloy (Modified 3310) they first succeeded in obtaining progressively higher tonnages to the 5,000,000-plus tons of rolled steel production enjoyed today.

In addition, the Torrington Company uses the 52100 series of USS CARILLOY Steels. The types of 52100 steels used in through-hardening anti-friction bearings consist of grades similar to AISI 50100, 51100, and 52100. These steels have certain special characteristics such as wear resistance and compressive properties essential in bearings, which are obtained by adding varying amounts of chromium to high carbon steels.

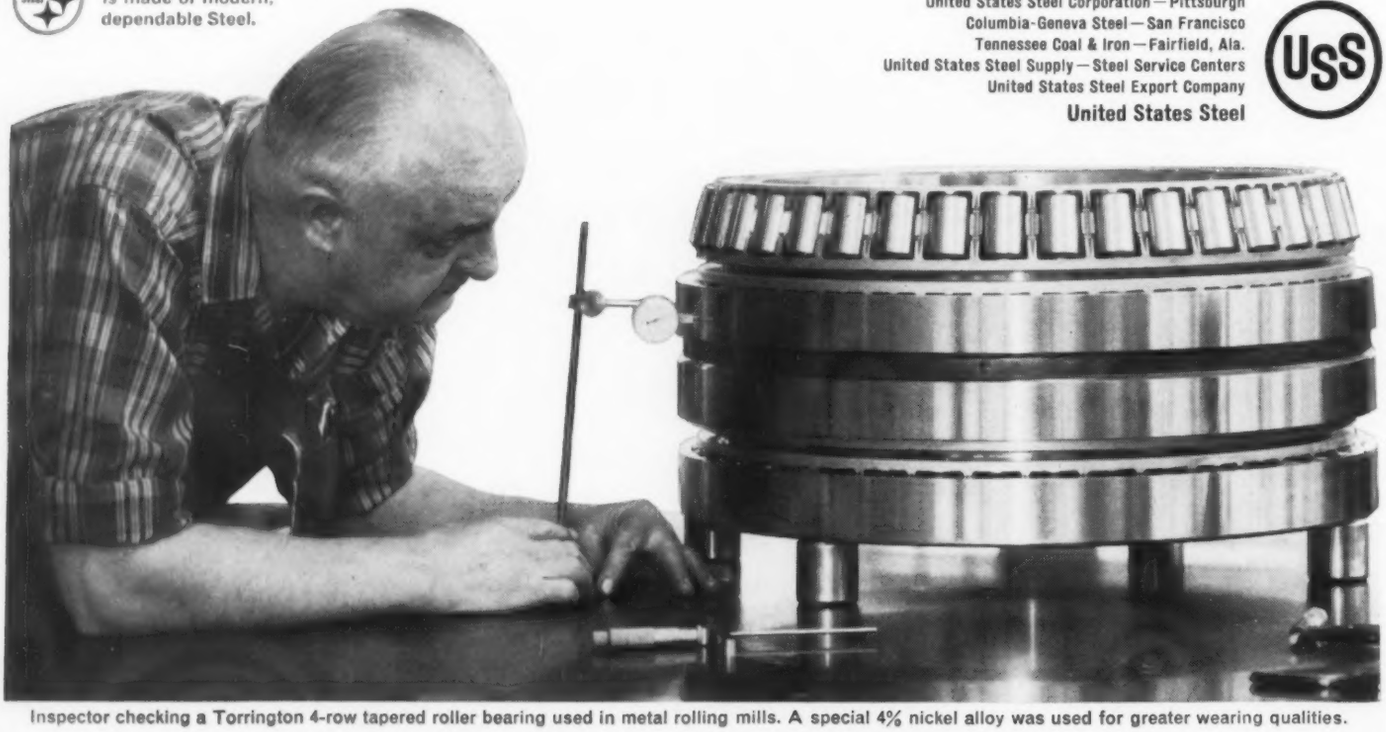
The chromium, manganese, silicon are varied according to the cross section involved in the finished part and its expected response to heat treatment, or the microstructure needed to impart wear and other special properties. USS CARILLOY Steels in this class have long been noted for their superior quality, cleanliness and wear resistance.

Special alloy steels such as those used by Torrington can be developed for other special needs. In addition, all standard alloy steel grades in a complete range of USS bar and semi-finished sizes are available. For more information, write United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS and CARILLOY are registered trademarks

This mark tells you a product is made of modern, dependable Steel.

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Ala.
United States Steel Supply—Steel Service Centers
United States Steel Export Company
United States Steel



Inspector checking a Torrington 4-row tapered roller bearing used in metal rolling mills. A special 4% nickel alloy was used for greater wearing qualities.

A MANSAVER COIL GRAB keeps smooth flow of coils

from exit end of Wean coil Preparation Line at Wheeling Steel Corporation's Yorkville Plant.

Here is another example of how proper equipment assures maximum production efficiency . . . the Mansaver style 1362 telescoping type coil grab carries coils from a Wean high speed coil preparation line quickly and with complete safety to both coils and workmen.

This Mansaver grab was designed for handling coils horizontally. The chain wheel readily adjusts the grab to any size coil. Due to the grab's simple, yet rugged construction, it provides Wheeling Steel Corporation continuous, trouble-free operation.

Ask our District Representative into your plant to study your problem for presentation for our solution.

MANSAVER INDUSTRIES, Inc.

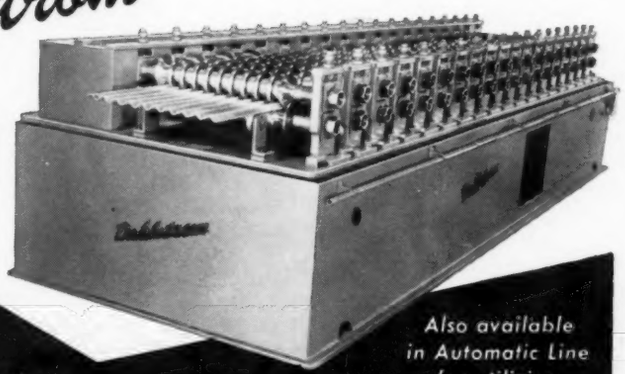
3116 East St.,
New Haven, Conn.

Also Manufactured in England by George W. King Co. and in France by Ets. Dujardin et Cie.

CORRUGATE SHEETS with a

Dahlstrom

ROLL FORMING MACHINE



FEATURING:

- All welded construction.
- Roll shafts mounted on anti-friction bearings.

Also available in Automatic Line for utilizing coil stock.

Major Building Products Manufacturers use this setup for corrugating 20 through 28 gauge galvanized steel, plain and embossed aluminum.

Requires only vertical adjustment for gauge range. Roller die tooling available for various depths. Excellent control of coverage and depth. No length restrictions.

Other gauge ranges also available. Send complete detailed specifications for quotation.

DAHLSTROM also manufactures a complete line of equipment for fabricating Coil and Sheet Metal.

- **ROLL FORMING MACHINES**
- **SLIDING DIE-TYPE CUT-OFF PRESSES**
- **COIL REELS**
- **COIL LIFTS**
- **ROLL STRAIGHTENERS**
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- **DECOILING AND SHEARING LINES**

Dahlstrom **MACHINE WORKS**
INCORPORATED

4226 W. Belmont Ave., Chicago 41, Ill. Phone: SPring 7-3670

Improve operating efficiency of electric furnaces with Pennsylvania PRESELECTIVE HEAT CONTROL

It changes transformer taps in seconds

1 trip the supply breaker. 2 run the transformer tap changer to the new position. 3 reclose the supply breaker.

In little more time than it takes to read the above procedure, you can adjust the voltage to change the furnace heat with Pennsylvania's new coordinated tap changer* and control systems*. Positive interlocks prevent any chance of trouble from improper operation.

Preselected Operating Taps Easily Changed

In a matter of seconds, you can preselect the automatic stopping points for remote control of the tap changer. Once initiated, the tap change is automatic to the next *selected* position. Jumper connections in the transformer control compartment are easily changed to set up a new series of heat (voltage) levels.

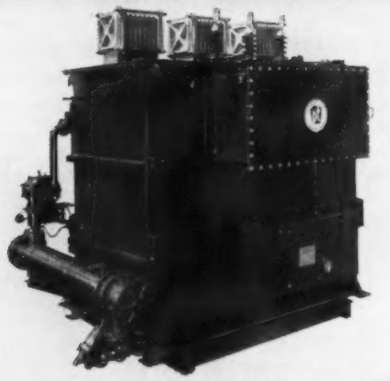
Successive Selector Switch Positions in 2⅓ Seconds

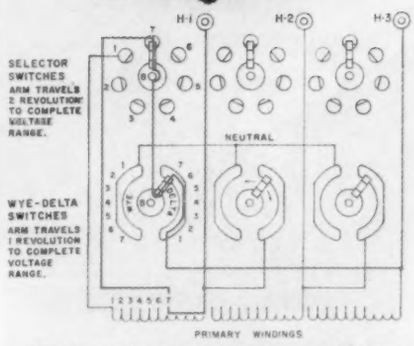
No limit switches—no mechanical stops. You can run the new 880A tap changer in either direction to the next desired tap position, whether with delta or wye winding connection. You can take the shortest direction at a speed of 2⅓ seconds per selector position, and you *stop* and *stay* on position because the geneva-gear direct drive is positive positioning and self locking.

Over 1,000,000 Tap Changes . . . With No Need For Maintenance

The new 880A tap changer, built especially for furnace transformers but of proven basic parts, was given an endurance test of over 1,000,000 tap changes. The result: Neither contacts nor mechanism showed any need for maintenance! Silver alloy-to-copper contacts contribute to the long service life you can expect from this rugged tap changer.

For technical assistance or a quotation on your next furnace transformer requirements, write on your company letterhead to Power Sales Department, Pennsylvania Transformer Division, McGraw-Edison Company, Canonsburg, Pennsylvania.





Top: Control equipment for type 880A tap changer showing jumper connections being made for selected remote control positions.

Middle: 6000 kva, class FOW cooled (forced oil and water heat exchanger) furnace transformer with motor-operated tap changer.

Bottom: Schematic of tap changer main connections. Tap and delta/wye switches can rotate either way to any position.

*Patent pending

McGRAW EDISON PENNSYLVANIA FURNACE TRANSFORMERS

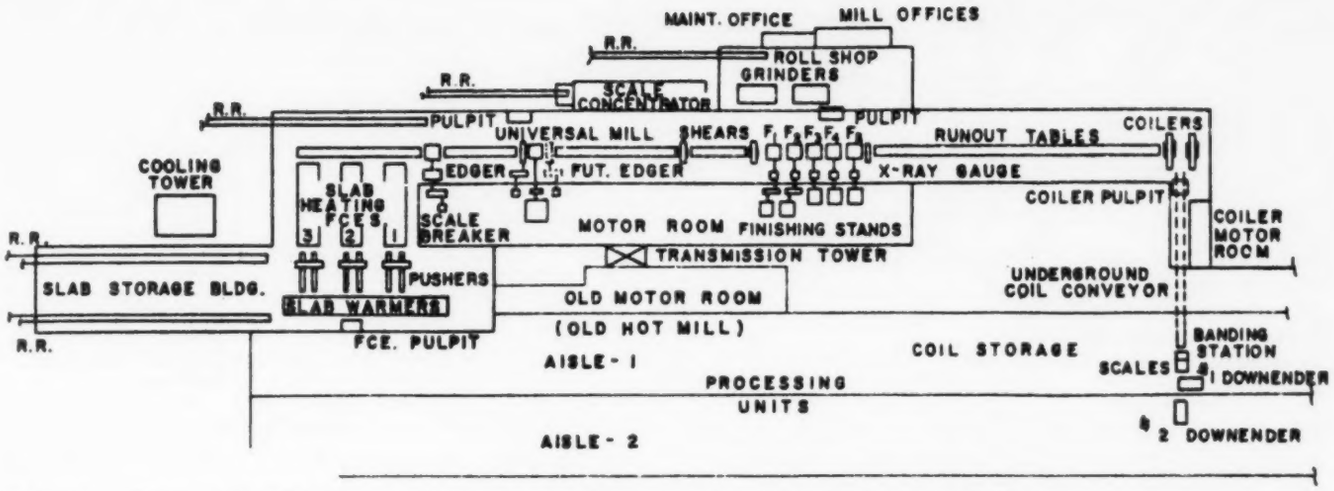


Figure 1 — The main building was lengthened to 918 ft to permit installation of the new mill.

Salient Features of Armco Steel's New Hot Strip Mill, Butler Works

The need for a wider, heavier and faster mill was obvious— the installation difficult—the results rewarding.

by C. H. ROBERTS, Supervising Mechanical Engineer,

and T. M. KILGO, Senior Electrical Engineer, Butler Works, Armco Steel Corp., Butler, Pa.

C. H. ROBERTS

T. M. KILGO

THE Butler Works started to roll strip steel on their 28 x 48-in. reversing rougher and 16 in. x 32 in. x 42 in. finishing mill in the original hot mill on October 26, 1926. The slabs were then heated in two 17 ft-6 in. 48 ft-0 in. long furnaces. Since that date, Armco has made many changes in the original equipment to meet the ever increasing demands of the trade. However, in 1954, after balancing the required changes on the old mill against a new mill to meet the production demands, it was necessary to immediately consider a wider, heavier and faster mill than the then existing 1300-fpm equipment.

This paper will describe the salient points or features that were encountered in the design of that specialty rolling mill for coiled and flat rolled products, and information and tabulations listed are in the most part the results of these studies.

To create the required space for a new hot mill, the entire wheel forging and turning operation at Butler was moved to a modernized plant about two miles from its old location. The space vacated by this move was the area used for the new hot mill. The main building had to be lengthened 145 ft to obtain the 918-ft length required to house the new hot mill. Other changes and additions to buildings, to house the new hot mill are included later in this paper; but changes that were made to the melt shop, ingot stripping and handling, and slab rolling are not included. The new hot mill having a 36 x 54 x 58-in. reversing rougher and a five stand 25 x 54 x 58-in. finishing mill, was designed to produce hot rolled strip in coils from reheated carbon, silicon, chrome, and chrome nickel alloy slabs 8 ft-0 in. long, 12 to 52 in. wide and 4 to 8 in. thick, weighing 1450 to 16,750 lb maximum weight; and to produce strip 12 to 52-in. wide, 0.050 to 0.225 in. thick, having a 26-in. inside diameter and approximately 58-in. outside diameter coils with mill speeds up to 2040 fpm.

Figure 1 shows the plant layout.

The slabs are transported a distance of 1750 ft by rail from the 34 x 56-in. slab mill, using either of two running tracks; and stored in a new 336 ft-0 in. long x 84 ft-0 in. wide slab storage building serviced by two

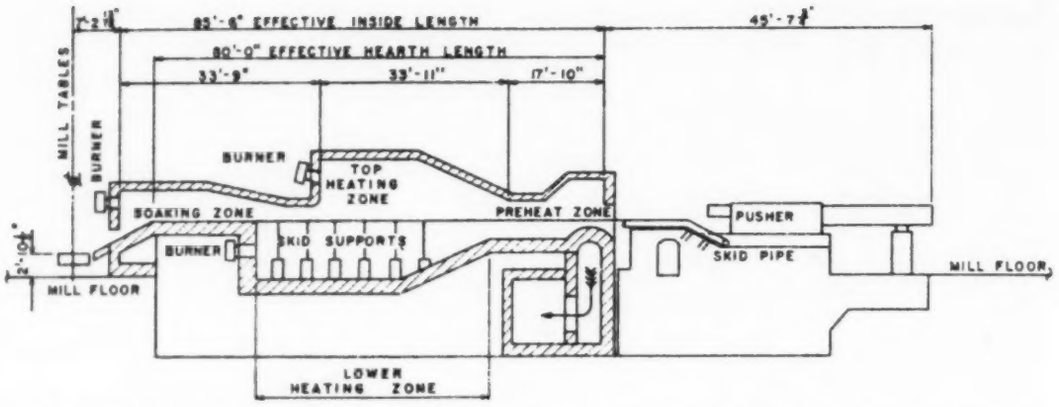


Figure 2 — Three continuous slab heating furnaces supply slabs at precisely controlled temperatures to the mill.

25-ton overhead cranes. This building has a storage capacity of 12,000 tons. The slabs are taken individually from storage and placed on the furnace pusher skids by magnet, if the material is common steel, silicon or chrome; or a type of automatic tong is used if the material is nonmagnetic stainless. Either crane can unload the cars, stock the storage building, or charge the furnaces.

All slabs are heated in one of three triple fired gas/oil continuous pusher type slab heating furnaces shown in Figure 2. These furnaces have an inside chamber width of 21 ft-0 in., an inside chamber length of 85 ft-6 in., with an effective hearth total length of 80 ft, of which the soak hearth length is 20 ft-0 in. The slabs are pushed through the furnace by a double furnace pusher, have a 15-ft stroke and exerting a total force of 456,000 lb. The force exerted to push 60 ft of the slabs along the wet skids is not exerted against the furnaces foundation or frame of the furnace, but differs in that the design of the holding base of the wet skids is incorporated in the base of the pusher drive. Each furnace design is based on an hourly heating rate of 100 tons of carbon steel per hour. The discharge or soak zone has a maximum heat input of 48,000,000 Btu per hr from eight 3 in. long flame cold air burners, the top and bottom zones have a maximum heat input each of 72,000,000 Btu per hr. Each one of these three zones are individually metered; have individual temperature control indicated by one of four radiation pyrometers, and at the discretion of the operator, can be controlled from any one of the four points in each zone.

The gas line to each furnace has its own shutoff valve and safety spool, and the main gas line to all furnaces has a main shutoff valve and a safety spool. Studies also indicated that a second supply of fuel was imperative for continuous operation, and all of the burners can be changed over to bunker "C" oil in case of an emergency, which can be done at the maximum rate of 20 min per zone. Each furnace is also metered for a total of 200,000,000 Btu per hr, and cold combustion air is furnished each furnace by a 40,000-cfm blower. Burnt gases are removed from each furnace by a 7 ft-0 in. diam x 150 ft-0 in. high brick lined stack by natural draft, controlled by a water cooled butterfly type damper. The preheat zone of the furnace covers a distance of approximately 18 ft from the back of the furnace and the lowest point of the roof is 3 ft-6 in. above the hearth. The top heating zone is approximately 34 ft-0 in. long, the highest point of the roof is 8 ft-6 in. above the hearth. The soaking zone is approximately 28 ft-0 in. long and the roof is 5 ft-6 in. above the hearth.

The slabs are pushed from the furnace and drop down a slope from the hearth floor 7 ft-5 in. below to the top of a 14 in. diam by a 58-in. long solid roll, the shock of which is cushioned by a cradle type bumper which extends the full length in front of each furnace.

TABLE I
Chart of Roll and Bearings of Scalebreaker and Mill Stands

	Diameter, in.	Bearing size, in.	Bearing width, ft-in.	Over-all roll Length, ft-in.
Scalebreaker work rolls	36	22½ x 32 x 23⅜	7-9 and 3-4¼	15-1
Scalebreaker feed roll	15	7⅜ x 10⅝ x 8 5/16	7-9	10-10 13/32
Reversing mill backup rolls	54	32½ x 46 x 33¼	8-6 and 5-0	18-0
Reversing mill work rolls	36	24 x 31 x 14¼	7-11 and 3-2⅛	15-1
Reversing mill feed rolls	16	9 29/64 x 14 11/64 x 10	7-1 and 3-2	11-3 13/16
Reversing mill edging rolls	28	13⅛ x 18½ x 6 9/16	3-3 and 2-5¾	5-5
Finishing mill backup rolls	54	32½ x 46 x 33¼	8-6 and 4-4¾	18-0
Finishing mill work rolls	25	16⅛ x 1½ x 13 3/32	7-11 and 2-4¼	13-8

TABLE II
Pertinent Data on Mill Housings

Location	Window width, in.	Window depth, ft-in.	Shoe spread, ft-in.	Shoe width, in.	Screw pitch and diameter, in.	Screw pressure maximum Starting torque, lb	Housing post, sq. in.	Screwdown speed, in. per min	Separating force, lb
Scalebreaker	42	10-0½	7-3	15	½ × 14 PD	224,000	510	7¼	4,500,000
Reversing mill	63	18-10	9-5	18½	1 × 18 PD	517,000	899	25.4	6,000,000
Finishing mill	60½	16-7	9-5	18½	0.4 × 17½ PD	6,750,000	877	0.825	5,000,000

TABLE III
Spacing of Main Components

Unit	Spacing, ft-in.
No. 1 furnace to No. 3 furnace	84-0
No. 1 furnace to 2-high scalebreaker	39-0
2-High scalebreaker to 4-high reversing mill	99-3
4-High reversing mill to 27-in. edger	7-9
4-High reversing mill to upcut shear	151-3
Upcut shear to rotary crop shear	58-1
Rotary crop shear to pinch roll scalebreaker	8-8
Pinch roll scalebreaker to No. 1 finishing stand	15-9
No. 1 finishing stand to No. 5 finishing stand	76-0
No. 5 finishing stand to No. 1 coiler	310-11
No. 1 coiler to centerline of coil conveyor	22-6
No. 1 coiler to No. 2 coiler	11-3
No. 3 furnace to centerline coil conveyor	854-2
Centerline of runout table to centerline of No. 1 downender	230-10¾

TABLE IV
Operating Surface Speeds

	Section length, ft-in.	Roll size, in. diam, length	Spacing of rolls, ft-in.	Surface speed, fpm	Roller structure
Furnace dropout table	106-0	14 × 58	2-0	340 max.	Forging
Scalebreaker entry table	27-6	14 × 58	2-0	340 max.	Forging
Scalebreaker work roll	11-0	36 × 58	5-6	198	Alloy cast steel
Scalebreaker feed rolls	3-0 mill	15 × 58	3-0	196	Forging
Mill approach table	40-0	15 × 58	2-6	375/950	Forging
Front mill table	40-0	15 × 58	2-6	375/950	Forging
Reversing mill work rolls	21-0	36 × 58	11-3 and 6-9	377/943	Alloy iron
Reversing mill feed rolls	4-0 mill	16 × 58	4-0	360/900	Forging
Back mill table	44-6	15 × 58	2-6	375/950	Forging
Mill runout table	45-0	14 × 58	3-0	375/950	Forging
Shear approach table	45-0	14 × 58	3-0	375/950	Forging
Finishing mill approach table	51-0	14 × 58	3-0	375/950	Forging
Pinch roll scalebreaker	5-0	14 × 58	2-6	0/1020	Forging
Finishing stand	13-3	25 × 58	19-0	300/600	Alloy iron
Finishing stand	19-0	25 × 58	19-0	445/890	Alloy iron
Finishing stand	19-0	25 × 58	19-0	622/1244	Alloy iron
Finishing stand	19-0	25 × 58	19-0	820/1640	Alloy iron
Finishing stand	19-0	25 × 58	19-0	917/2030	Alloy iron
Runout table	288-11	12 × 60	1-6	2340 max	Centrifugal cast iron
Pinch roll No. 1 coiler	3-0	20 × 66 (bottom)	3-0	2235 max	Centrifugal cast iron
No. 1 coiler mandrel	8-0	26 × 66	8-0	2460 max	Steel cast
No. 1 coiler blocker rolls	11 centers	105½ × 66	0-11	2460 max	Cast alloy
Table over coiler	36	12 × 60	18-0	2340 max	Centrifugal cast iron
Pinch roll No. 2 coiler	3-0	20 × 66	3-0	2235 max	Centrifugal cast iron
No. 2 coiler mandrel	8-0	26 × 66	3-0	2460 max	Steel cast
No. 2 coiler blocker rolls	11 centers	105½ × 66	0-11	2460 max	Cast alloy

The top of all table rolls is 2 ft-10½ in. above floor level, and 1½ in. below the mill pass line. These table rolls are on 2-ft centers, and the spaces between the rollers are open allowing scale to drop into a sluice, supplied with 2700 gpm maximum flow of water. A chart showing all of the mill equipment is shown in Table I. Pertinent details of each are listed in Tables II, III, and IV.

Referring to the mill layout as shown on Figure 1, the three hot mill furnaces are located in a new 61 ft-0 in. wide by 143 ft-0 in. long building which connects the main hot mill aisle and the slab storage building.

The main hot mill aisle is in a 70 ft-0 in. wide x 918 ft-0 in. building and the centerline of the roll train is 30 ft-0 in. from the south or motor room wall. It is serviced by three cranes, a new 75/25-ton, a new 50/10-ton, and an existing 15/5-ton crane, whose track rails are 34 ft-6 in. above floor. The 75/25-ton and the 50/10-ton cranes service the mills handling the chocks and porter bar for backup and work roll changes.

The oil cellar located on the south side of the roll train contains four separate hydraulic roll balance systems for the scale breaker, the reversing mill, finishing mill and pull backs on the finishing mill side guides; with the oil lubricating systems given in Table V.

TABLE V
Oil Lubricating Systems

System	Gal
Screwdown and pinion stands of the reversing mill	1,500
The front and back mill tables and edger	2,500
Mill approach and runout tables, shear approach, finishing mill	4,500
Pinion stands and screwdowns on the finishing stands	4,500
The two finishing mill drives	1,000
Screwdown, pinion stand and drive on scalebreaker	1,500
Total	15,500

TABLE VI
Cooling Water Distribution

Location used	Purpose or part cooled	Amount of water, gpm	Remarks
Three slab heating furnaces	Skids, damper	9,200	Recirculated through 10,000-gpm tower
Scalebreaker	Roll cooling 20½-in. nozzle at 20 gpm	400	Mill supply from reservoir goes to hot mill concentrator pit.
Reversing mill	Roll cooling 52⅜-in. nozzles at 12 gpm	625	Mill supply from reservoir goes to hot mill concentrator pit.
Finishing mill	Roll cooling 128⅜-in. nozzles at 12 gpm	1,500	Mill supply from reservoir goes to sewer
Oil cellar	Oil cooling	400	Discharges into hot mill concentrator pit
Runout table	Strip cooling	7,325	Goes to recirculatipn pit 3 top sprays at 1200 gpm = 3600 gpm 3 bottom sprays at 1240 gpm = 3720 gpm
Two coilers	Strip cooling	1,000	Cools mandrel and blocker rolls, goes to sewer
		20,450	Available

Roughly 6000 to 9000 gal of cooling water is used for the production of every ton of product rolled in the department.

Fire protection to the oil cellars consists of an automatic water spray or fog system operated by twenty rate-of-rise heat actuated devices, or four remote manually-operated tripping stations, the water supply to the system coming directly from the mill reservoir supply. The oil cellars are ventilated by fans located at mill floor level, drawing the air from the cellar ceiling area, so that the air enters the cellars at the door areas moving through the cellars to the fans, air moving in all parts of the oil cellars and giving adequate ventilation at a controlled rate of each oil cellar of 8000 to 32,000 cfm. These fans are interlocked with the fire protection system so that they automatically shut down in case of fire.

COOLING WATER DISTRIBUTION

The 1200-psi hydraulic descaling system is also located in the oil cellar and consists of three 750-gpm pumps, and acting with a 32-in. diam x 22-ft long bottle serves the scalebreaker, reversing mill and the pinch roll table type scalebreaker in front of the finishing mills. The scale-laden water from these units travels through a sluice into a double settling pit where the scale settles to the bottom of the pit and is removed by chain conveyors, and then deposited into gondola RR cars. The water is recirculated by two of three 3500-gpm 60-psi pumps at the average rate of 7000 gpm.

Figure 3 — Some 1500 gpm are applied to the finishing mill work rolls.

The Butler Works obtain their water supply from the Connoquenessing Creek, which unfortunately has a flow rate of less than 5,000,000 gal per day for 17.6 per cent of the year. Tabulated in Table VI are the demands and sources of supply of cooling water, showing the method used to meet this problem.

Each work roll has one total spray and one 3-section spray on each side set at 20 and 37 degree angles respectively (Figure 3). The discharge cooling water from the finishing stands goes into the main mill sewer through a scale trap.

The cooling water on the runout table can be supplied to the top and bottom of the strip for a 200-ft distance of the 288 ft table as shown in Figures 4 and 5. This water is in a closed system, water being taken from a 115,000-gal sump adjacent to and under the runout table by means of three 3000-gpm, 150-ft head pumps and supplied to three top and three bottom individually controlled headers.

Sprays are on 18-in. centers and the top sprays are located at alternate positions at each side of, and three ft above, the table forming a fan pattern across the strip, and because of its side application, carries the heat away from the strip. A 50-degree angle vee jet nozzle is used to give this pattern.

Cooling air can be supplied and equally distributed to the coiler pit at the rate of 64,000 cfm maximum.

Compressed air headers are incorporated in each side of the buildings referred to above, and acetylene gas and oxygen service runs the entire length of the hot mill and roll shop.

THE ROLL SHOP

All of the rolls are ground and chocks and roll bearings are serviced in 61 ft wide x 231 ft long roll shop shown in Figure 6 which is serviced by a 60-ton crane. Rolls are ground on a new 60-in. swing x 216-in. long grinder or a 50 x 216-in. grinder relocated from the old hot mill. Floor space and roll racks were provided in the roll shop and the mill aisle for a minimum of six scale breakers, 16 reversing mill work rolls, 90 finishing mill work rolls and 36 backup rolls; four scalebreaker chock assemblies, four reversing mill work roll chocks, 20 finishing mill chock assemblies and 20 backup chock assemblies. Space for spare bearings for each roll chock was also provided. Storage had to be provided for a minimum of 85 spare items of equipment to be on hand

Figure 4 — Water sprays on the runout tables form a fan pattern across the strip.

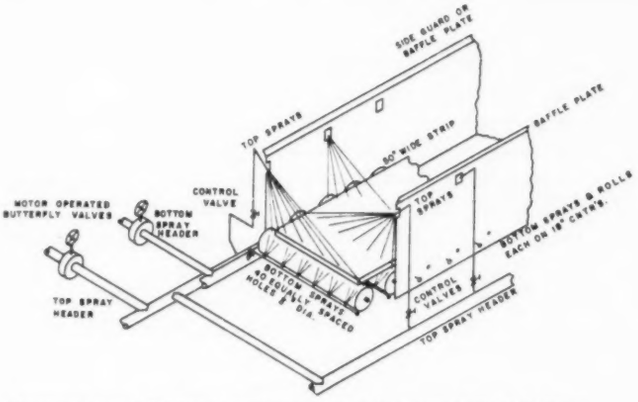


Figure 5 — Schematic of runout table coolant piping.

prior to startup, 110 spares for immediately after startup and 200 insurance or long range spares.

VAPORS ARE REMOVED

Smoke or excessive fume laden vapors are removed at the reversing mill and finishing stands by fans drawing the air through water cleaning units, each hood removing 15,000 cfm. These hoods are located on the discharge side of the mills, are designed to give free access to the working area and are in addition to a 4 ft-0 in. wide continuous ventilator at the ridge of the building roof.

COIL HANDLING

The hot rolled coils are extracted from each down coiler, placed on one of two rams, then placed on a hydraulically actuated hoist, which is part of the upender located directly between the centerline of the coilers. These two rams move from the centerline of the coilers and turn 180 degrees while traveling 11 ft-3 in. to the center line of the coil conveyor.

The coil conveyor, moving at 6 ft-8 in. increments, carries the coils on end underground through two buildings and rises to floor level in the third building, a distance of 200 ft to a banding and weigh station. The coil is then placed on a ramp by either of two downenders into either No. 1 or No. 2 mill aisles.

The conveyor troughs or skids are on 30 in. center and the links on 18-in. pitch, the 10 x 17-in. face plates of the conveyor leave but 14 in. of the 34-in. spread of

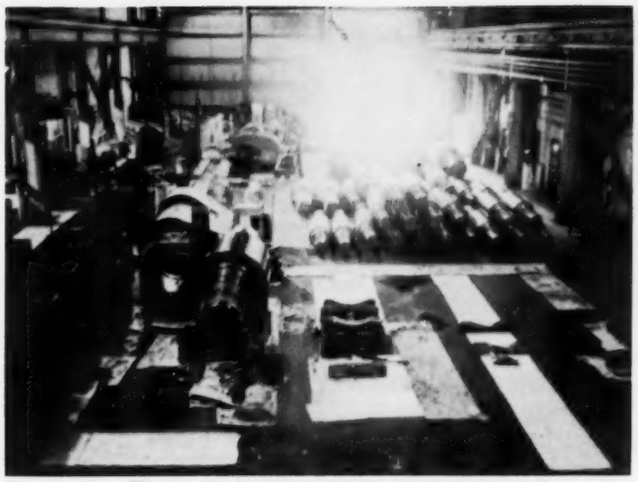


Figure 6 — The roll shop provides storage space for spare rolls, chocks and bearings.

Figure 7 — Smoke and vapor are removed at the reversing mill through a hood on the discharge side of the mill.

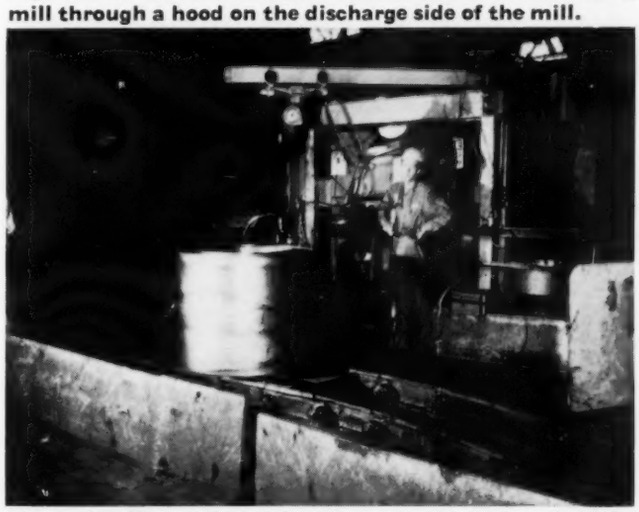


Figure 8 — The coils are banded and weighed during the transfer from the coilers to the storage area.

the conveyor unsupported, and the friction from the face plates keeps the coil tight while being moved on the conveyor. The movements of the conveyor, upenders, weighing device and downenders are all interlocked for safety reasons. The conveyor moves at the rate of 41 fpm, and holds 30 coils or approximately 250 tons when in full operation. The upenders, the coil unloader and the downenders are hydraulically-actuated, and individually powered by 750-lb pressure units.

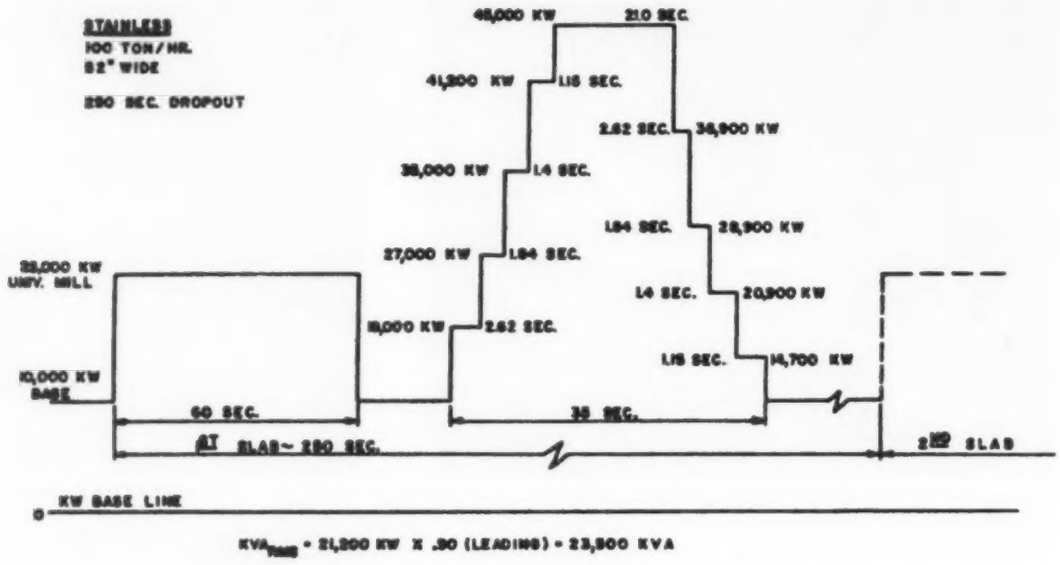


Figure 9 — Typical RMS curve for hot mill 25000-kva bank.

The weighed and banded coils as shown in Figure 8 are deposited in either of two buildings, serviced by the downenders and are taken by crane or by tractor from there for further processing.

POWER DISTRIBUTION

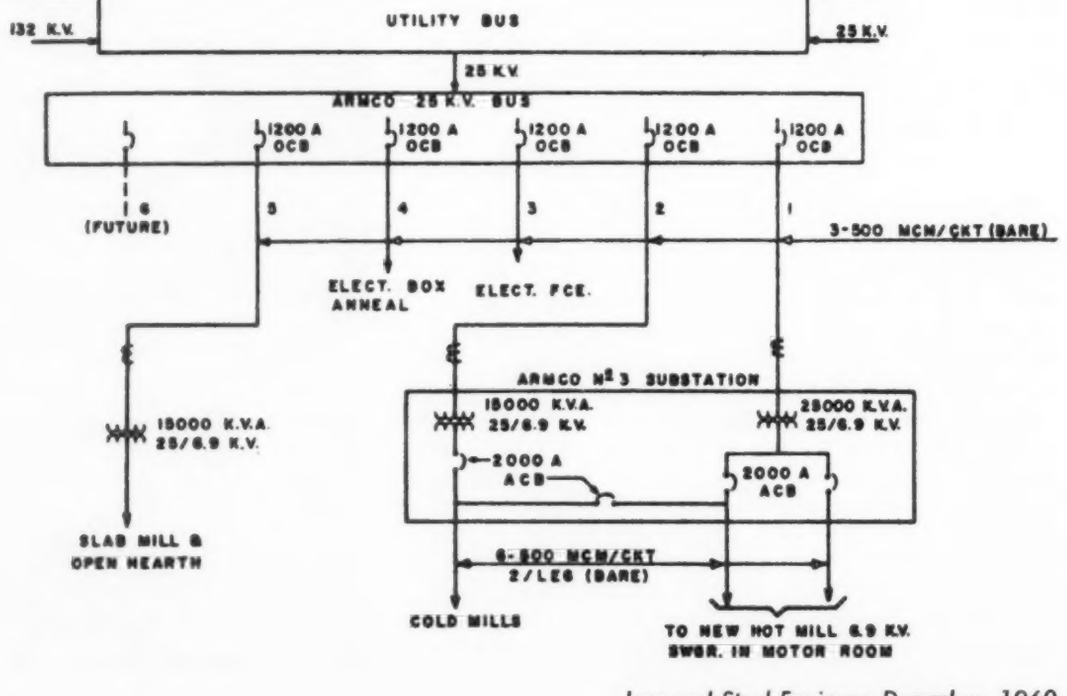
Electrical power for the new hot mill is supplied from a new 25,000-kva 25,000/6900-volt power bank which consists of three 8333-kva, single-phase, 60-cycle transformers. Cooling fans enable the bank to deliver 30,000 kva if required. Figure 9 shows a typical RMS curve used to determine the transformer capacity required.

The 25-kv power to the new 25,000-kva bank is fed over an existing overhead circuit. This circuit consists of three single conductors, 500 million cir mils, bare copper conductors from the utility substation to the No. 3 substation in which the new 25,000-kva bank is located. Figure 10 shows power distribution to new hot mill.

It was possible also to use an existing 6900-volt circuit from the 25,000-kva bank to the new hot mill area. This circuit consists of twelve single conductors, 500 million cir mils, bare copper conductors from No. 3 substation to a dead end tower located outside of and adjacent to the old hot mill motor room.

For the new hot mill, this existing circuit was made into two circuits, each consisting of two 500 million cir mils conductors per leg. A new 2000-amp air circuit breaker was installed at No. 3 substation for the additional circuit. The existing 2000-amp air circuit breaker was used for the remaining circuit. Since the new hot mill motor room is located adjacent to the old hot mill motor room, only minor changes were necessary to utilize the existing dead end tower located between the old and the new motor rooms. An incoming bus structure was installed on the roof to the

Figure 10—Schematic shows plant power distribution system.



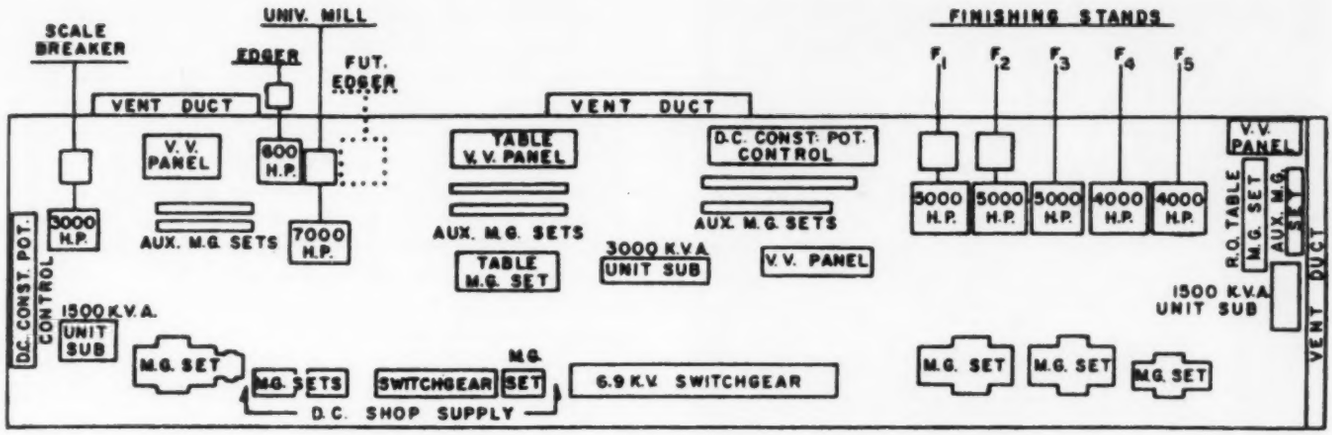


Figure 11 — Layout shows main motor room for 58-in. hot strip mill.

new motor room. The two 6900-volt circuits were continued from the dead end tower to the new bus structure on the motor room roof. From the roof bus structure the circuits are connected to two 2000-amp, 15-kv, 3-phase bus duct risers which enter the incoming line cubicles of the new 6.9-kv switchgear located on the main floor of the new hot mill motor room.

MOTOR ROOM

The motor room, see Figure 11, contains the 6900-volt metal-clad switchgear, the main power supply motor-generator sets, the auxiliary and control motor-generator sets, the 250-volt, d-c shop supply motor-generator sets and their associated switchgear, main mill control panels, the mill main drive motors, the unit substations, and motor control centers for 440-volt a-c auxiliaries and the plant power totalizing metering panels. Figure 12 shows an over-all view of the motor room. Figure 13 is of the west end of the motor room showing the universal mill main drive motor and power supply motor-generator set. Figure 14 shows the finishing mill main drive motors and their power supply motor-generator sets.

The new 6900-volt switchgear consists of 29 cubicles. The switchgear contains two 2000-amp bus sections, each fed through a 2000-amp incoming line air circuit breaker. The bus sections are connected by a 2000-amp tie breaker. The switchgear includes, in addition to the incoming line breakers and the bus tie breaker, the 6900-volt breakers for all unit substations, lighting load centers and starting switchgear and control for the synchronous motors driving the main power supply motor-generator sets and the 250-volt d-c shop supply motor-generator sets. All breakers have an interrupting rating of 500,000 kva at 6900 volts and are of the removable horizontal drawout type.

Four main motor-generator sets supply variable voltage d-c power to the main mill drives.

1. A 6600-kw, four unit synchronous motor-generator set supplies the reversing rougher and the vertical edger. The set consists of two 3000-kw, 700-volt, d-c generators, one 600-kw, 700-volt d-c generator and a 9000-hp, 360-rpm, 6900-volt synchronous motor. The two 3000-kw generators operate in parallel to supply the reversing rougher 7000-hp main motor. For load balance the generators have differential and cross connected cumulative series fields.

The 600-kw generator has capacity for two 600-hp edger motors, with only one motor loaded at one time. At present the mill has only one edger.

2. Two 8000-kw, three-unit, synchronous motor-generator sets supply finishing stands No. 1, 2, 3, and 4. Each of these sets consists of two 4000-kw, 700-volt d-c generators and a 11,200-hp, 300-rpm, 6900-volt synchronous motor. Each generator supplies one of the main motors driving finishing stands No. 1 through 4.

3. The power supply for stand No. 5 is from an existing 3000-kw, four unit synchronous motor-generator set, consisting of two 1500-kw, 600-volt, 600-rpm d-c generators and a 4200-hp, 6600-volt synchronous motor. For load balance the generators have cross connected series field.

All of the synchronous motor drives for the main power supply motor-generator sets have neutral reactor starting and differential relay protection. The neutral starting reactors are located in the motor room basement. All new synchronous motors have 0.9 power factor selected because maximum pullout is obtained at low excitation. Also sufficient power factor correction is available at 0.9 power factor.

Four 1500-kva, 6900/460-volt, 3-phase unit substations supply 440-volt, three-phase, 60-cycle power for a-c auxiliaries. Each unit substation is located convenient to the area which it serves.

A 3000-kva, 3-phase, 60-cycle, 6900/2300-volt unit load center located in the motor room supplies 2300-volt, 3-phase power required by the drive motors for the high pressure descaling sprays, air compressors and coiler motor-generator set drives.

The 250-volt d-c shop supply is furnished by two 750-kw and one 1000-kw motor-generator sets. These are existing units. New 250-volt d-c switchgear was provided for these units and for the shop supply feeders.

To provide control for 440-volt a-c auxiliary drive motors, motor control centers are located convenient to the areas which they serve. There are a total of 13 of these motor control centers provided for the new hot mill. Motor room lighting is combination incandescent and mercury vapor. Motor room ventilation is by an updraft modified nonrecirculating forced ventilation system.

The fresh air intakes for the motor room ventilation are located above the motor room roof. Three vertical ducts extend down the motor room walls to take the fresh air down to oil bath filters and the ventilating fans located in the basement. Adjustable louvers are

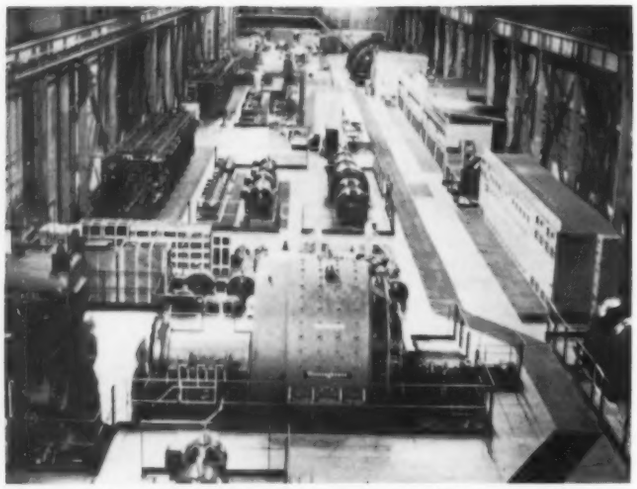


Figure 12 — The motor room is ventilated by 24 fans operating in three banks of eight each.

Figure 13 — The mill drive motor and the motor-generator set for the reversing rougher occupy the west end of the motor room.

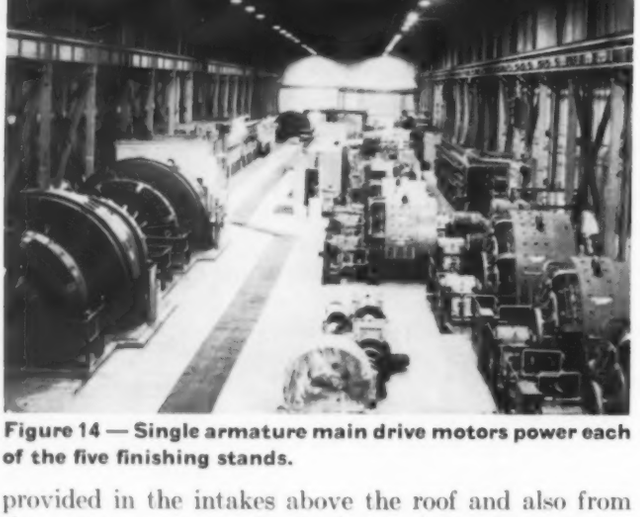


Figure 14 — Single armature main drive motors power each of the five finishing stands.

provided in the intakes above the roof and also from the motor room to the fresh air ducts. This makes it possible in cold weather to adjust these louvers and recirculate part of the air to keep the motor room comfortable in cold weather. Also provided are 13 motor driven, wall mounted exhaust fans which are used to remove the warm air during normal warm weather operation. The fresh air intake fans consist of 24 axial-flow fans which deliver a total of 708,000 cfm at $1\frac{3}{4}$ in. pressure. These fans are divided into three groups, eight fans to a group for each of the three intake ducts.

The control for all ventilating fan drive motors is provided from motor control centers. Each of these control centers has an electrically operated main breaker which is interlocked with a fire detection system to shut down the entire motor room ventilating system in case of fire. In addition a water spray system is provided at the oil bath filters which is also actuated automatically in case of fire in the filter area.

SCALEBREAKER

The roughing scalebreaker is nonreversing and is driven at a constant speed of 175 fpm by a 3000-hp 6600-volt, 3-phase, 60-cycle 505-rpm induction motor. Slabs are given one heavy pass through the scalebreaker on their way to the universal roughing mill. The drive was selected so that on stainless rolling a 10 to 15 per cent reduction pass could be made on this mill.

UNIVERSAL ROUGHER AND EDGER

The reversing universal roughing mill consists of a four-high main horizontal roll stand driven by a 7000-hp, 700-volt d-c, 40/100-rpm reversing motor, and a vertical roll edger driven by a 600-hp, 700-volt d-c, 150/450-rpm reversing motor. The edger is on the entry side of the universal mill. The universal mill and the edger are controlled simultaneously from one master switch located in the universal mill pulpit. The speed range of the mill and edger is 377/942 fpm. The control of the edger is arranged so that the edger rolls are in contact with the slab only on the odd numbered passes. The vertical edging rolls are separated and out of contact with the slab during the even numbered passes. A second edger is to be installed in the near future on the delivery side of the mill.

A draft compensation rheostat is provided on the universal mill desk to change the edger motor speed by a fixed percentage corresponding to the per cent reduction being taken by the mill.

The universal mill screwdowns are controlled from the universal mill desk either manually or through "preset" screwdown control. This automatic preset screwdown control coordinates the positioning of the universal mill screwdowns and the positioning of the side guards of the scalebreaker, front and back mill side guards, and edger width adjustment.

The position of the screwdowns is preset on two schedule selector panels located in the universal mill pulpit. Two schedules may be set up and either may be selected by means of a transfer switch located on the main desk. A schedule may be set up on the schedule selector panel not in use without affecting the operation of the panel being used. When the "preset" screwdown control is used (which is the normal operation) the operator needs only to press the preset control "operate" button prior to each pass and the screwdowns come down to the "preset" position for each pass. After a predetermined number of passes the screwdowns return to set up for pass No. 1. The sideguards and edger adjust drives are also operated through relays on the schedule selector panel. On odd numbered

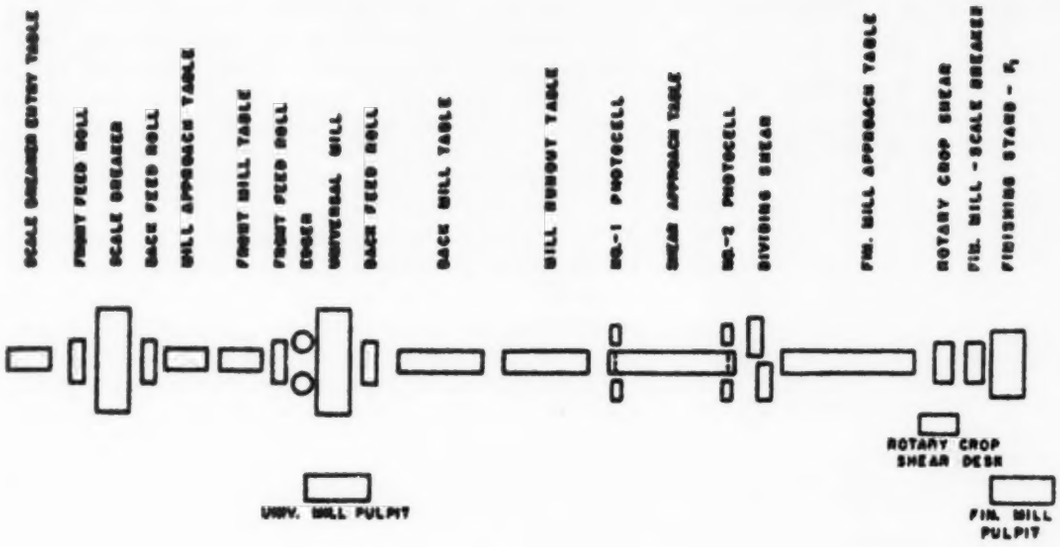


Figure 15—Schematic layout of mill tables.

passes the entry side guards and edger adjustment move in and the exit side guards move out. The opposite is true on even numbered passes.

MILL TABLES

The mill tables, see Figure 15 are divided into two groups. The first or universal mill group consists of the scalebreaker table, scalebreaker front and back feed rolls, mill approach table, front and back mill tables, universal mill front and back feed rolls and mill runout table. These tables are driven by adjustable voltage drives and are tied in with the universal mill through a pilot generator on the mill drive. The universal mill operator controls the tables and the universal mill from the universal mill master switch. There is also a separate table master switch for manual operation of the tables. The universal mill group operates at a maximum of 950 fpm with four steps or ranges of speeds which can be preset as follows:

Step	*Fpm*
1	100/300
2	300/500
3	500/700
4	700/950

The second or finishing mill group consists of the mill runout table, the shear approach table, finishing mill approach table and the finishing mill scale breaker.

The finishing mill group, with the exception of the mill runout table and the shear approach table, is controlled from the rotary crop shear desk which is located on mill floor ahead of No. 1 finishing stand. The finishing mill approach table is controlled from its own master switch located on the rotary crop shear desk. Speed steps obtainable by means of this master switch are as follows:

Step	*Fpm*
1	50/150
2	90/250
3	475

The finishing mill scale breaker also has its own master switch on the rotary crop shear desk which provides the following speed steps:

Step	*Fpm*
1	50/150
2	90/450

The mill runout table and the shear approach table are set up to operate with either the universal mill group or with the finishing mill group. Two photocells, one at each end of the shear approach table, switch the control of these tables between the two groups. When a bar being rolled in the universal mill covers photocell 1, the shear approach table is transferred to and operates with the universal mill group. When the bar covers both photocells, both the mill runout table and the shear approach table are transferred to and operate with the finishing mill group. As the bar continues toward the finishing mill and uncovers No. 1 photocell, the mill runout table is transferred back to the universal mill group. When the bar leaves the shear approach table uncovering No. 2 photocell, the shear approach table is also transferred back for speed matching with the universal mill group.

Automatic draft compensation is provided for the tables in the universal mill group. Draft compensation speeds of approximately 10, 20 and 30 per cent may be

TABLE VII

Stand No.	Motor hp	Motor rpm	Gear ratio	Roll rpm	Roll fpm	Generator kw	Generator volts
F-1	5000	125/250	2.72:1	45.75/91.5	300/600	4000	700
F-2	5000	125/250	1.84:1	67.9/135.8	445/890	4000	700
F-3	5000	95/190	Direct	95/190	622/1244	4000	700
F-4	4000	125/190	Direct	125/250	820/1640	4000	600
F-5	4000	140/310	Direct	140/310	917/2030	3000 (2-1500 kw)	600

selected by the operator to suit the rolling schedule being used.

FINISHING MILL

The finishing mill consists of five four-high mill stands, located on 19-ft centers, with work rolls 25-in. nominal diameter by 58-in. face and back up rolls 54-in. nominal diameter by 58-in. face. Table VII shows a tabulation of the motor ratings, method of drive, and mill speeds with 25-in. nominal diameter rolls for the finishing mill.

Each of the five stand drive motors has its own supply generator. These generators are individually controlled through the motor operated rheostat of the individual stands.

The speeds of the stand drive motors can be varied by voltage output of the individual generators and by field weakening of the main drive motors. To expand the available speed range, all of the motors, or any one, can be operated at reduced voltage, down to 60 per cent of rated voltage. The control for the mill is arranged so that the five stands can be brought up or down in speed or stopped by a main mill master switch. In addition, each stand has its own individual master switch for adjustment of speed by voltage over the range of 60 per cent of rated voltage to full rated voltage. Each stand also has a vernier rheostat which provides a total range of 13 per cent variation in stand speed. Operation of the vernier can change the generator voltage from plus 5 to minus 8 per cent of the voltage established by the stand master switch.

RUNOUT TABLES

The runout tables consist of three sections. Section one consists of 66 3-hp, 250-volt d-c adjustable speed motors. Section two and section three are duplicates of section one with the exception that section three has only 60 3-hp motors. Each section has its own 200-kw generator. The three sections contain a total of 192 3-hp table roll drive motors.

Three types of operation are provided for each table section: jog forward and reverse, manual and automatic. During automatic table operation, the table speeds are matched automatically with the finishing mill delivery strip speed. The speeds of all three table sections are controlled from the coiler pulpit. The coiler operator, while controlling the speeds of all three sections, can start and stop only the last two sections. The starting and stopping of table section No. 1 is under control of the operator in the finishing mill pulpit.

COILERS AND COIL CONVEYOR

Coiling is by means of two mandrel type downcoilers, each of which consists essentially of a pair of motor-driven pinch rolls placed at table level, a nest of four pairs of motor-driven blocker rolls, and a motor-driven expanding and collapsing mandrel. An air-actuated stripper is provided for stripping the completed coil from the collapsed mandrel.

The pinch rolls for each coiler are driven by two independently connected 100-hp, 485/725-rpm, 230-volt d-c motors. The mandrel is driven by a 300-hp, 300/900-rpm, 230-volt d-c motor. Each pair of blocker rolls is driven by a 30-hp, 690/1030-rpm 230-volt d-c motor. Power supply for these motors is from a variable voltage power supply motor-generator set located in the coiler motor room. Synchronization of the coiler speed with mill delivery speed is accomplished by means of a signal provided by a pilot generator on the drive motor of the last finishing stand.

Two separate sets of control and power supply motor-generator sets are provided allowing the coilers to be operated independently of each other. Coil unloader at each coiler receives the finished coil, rotates and traverses to an upender which elevates, traverses and upends at the coil conveyor. A single coil conveyor serves both coilers. The conveyor transports the coils from the coiler pit to floor elevation where the coils are weighed and conveyed to coil downenders which dump the coils in the coil storage aisle where they are removed by a crane.

Discussion

PRESENTED BY

L. L. HALL, Superintendent, Hot Strip Mill, Republic Steel Corp., Warren, Ohio

C. H. ROBERTS, Supervising Mechanical Engineer, Butler Works, Armco Steel Corp., Butler, Pa.

LOUIS H. SUCH, Superintendent, Hot Rolling & Conditioning, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

T. M. KILGO, Senior Electrical Engineer, Butler Works, Armco Steel Corp., Butler, Pa.

C. A. SCHURR, Control Systems Engineer, Electric Controller & Mfg. Div., Square D Co., Cleveland, Ohio

A. F. KENYON, Advisory Engineer, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

A. L. LIND, Chief Draftsman, Rolling Mill Div., E. W. Bliss Co., Salem, Ohio

C. F. COBURN, Sales Engineer, Salem-Brosius, Inc., Pittsburgh, Pa.

CLIFFORD ELMS, Project Engineer, Blaw-Knox Co., Pittsburgh, Pa.

L. L. Hall: Is there a reason for not using slab depilers? We are planning a similar installation and we are wondering if we will run into any delay due to handling one slab at a time. What is your experience to date for charging in the above manner?

You spoke of having a 280-ft runout table and the amount of water you had for the cooling system. There is much discussion pro and con on proper application as to space on the side or top. What has been your experience from the side space? Also, what type of model are you using on this table?

C. H. Roberts: We felt that due to the grade of the material we were rolling, the method which we used, with a magnet or tongs individually loading the pushers, was the best method.

We went to several mills, some of our own company and some belonging to competitors and looked over the sprays that were used on the runout table. We found that the spray that was directly over the strip placed the water on the strip and this water acted as a blanket. Also we found in everyone of these installations, at the end of the runout table, they had an air spray drawing the water off the strip.

Therefore, we thought we would put in a spray on the side and let the spray go across and take the heat out of the strip as it went across. We have found this to be very effective. The operators can control the temperature pretty well with this system.

There are six different banks of sprays, three on the top and three on the bottom, and the pulpit operator can control any one of those banks.

Louis H. Such: I am particularly pleased to see an effort made to synchronize the various universal mill components by draft compensation on both the edger and table speeds in that area. Would you care to comment on the improvement on the bottom and edge mechanical damage as a result of this draft compensation. We presume that this was the primary intent in providing this feature.

Staying with the universal mill area, I have several other questions: On the even-numbered passes, that is, the bar going back toward the furnaces, on the intermediate and particularly the next to the last pass, when the bar is very long:

1. Does the bar encroach back onto the furnace tables, through the 2-high scale breaker? If it does:

a. Are the furnace table rolls contrarotating? That is, are these rolls kept rotating in the forward direction during all passes of the bar?

b. The 2-high scalebreaker is described as nonreversing. The question arises, are the feed rollers in this scale breaker also nonreversing?

2. Since the bar bottom is subjected to abrasion because of relative differences in speed, turn-down and bar weight in these locations, what percent or degree of severity of the bottom mechanical damage on the finished coil do you trace to these two conditions?

3. You mention the possibility of the installation of a second edger. Is this to:

a. Obtain better uniformity of width?

b. Obtain better edges?

c. Obtain more edging passes?

d. Are you proposing to actually diminish width and do sizing?

4. Do you consider the present dust removal system up to your expectations? If you do, do you intend to expand this onto the other stands also?

5. Throughout your various plants, you have hot strip mill installations with roller bearings and oil-film bearings on backup rolls; what was the reasoning in the selection of the bearings installed at this location?

C. H. Roberts: On Mr. Such's remarks concerning the next to the last pass in the reversing mill we developed with the mill equipment manufacturers a set of tripper rolls which are tied in with the control system and automatically rise, lifting the strip above the scalebreaker roll, and they extend enough to hold the strip up so that it does not touch the table roll in front of the scalebreaker. There is no damage whatsoever to the strip.

In regard to the second edger, it was thought that we could achieve a better control over the width, especially when it left the reversing mill.

As to the backup roll bearings, a study was also made; and, from our experience with anti-friction bearings in the old mill and from that and the information we obtained from our other mills, we selected anti-friction bearings.

T. M. Kilgo: We do plan to give the operator preset draft compensation for the edger for each pass. He presently uses an average setting which is the same for all passes.

We have the feed rolls that come up to lift the bar above the scalebreaker rolls tied in with our preset screwdown control so that the rolls are actuated on the sixth pass to prevent bottom side damage.

C. H. Roberts: When we were developing the dust system, for the reversing mill and the last three stands of the finishing mill, we reviewed our results from a dust removal system in our last stand of our old hot mill. We took several tests on that stand to determine how much air was needed, what volume of air had to be removed to give a good clear atmosphere there for the men, and the results ran between 13,000 to 15,000 cfm. We developed our fume removal system on that basis.

C. A. Schurr: In order to improve quality control and relieve operator fatigue on the universal roughing mill, it was decided to install programming equipment for position control of the main rolls. For this application, a high accuracy analog type of control system is used where programming is accomplished by slider type schedule selection panels. An adjustable voltage drive is used for control of the screwdown motor.

The use of the schedule panels permits direct programming of the control system without the complications of decoding networks and permits the operator to make modifications to the rolling program at any time by the simple manipulation of sliders. Provisions have been made for incorporation of a card reader system at a later date should this be desirable.

The range of programmed roll opening is from 0 to 10 in. and this is divided into increments of 0.025 in. To program any roll separation, it is necessary to set up two sliders, one in increments of 0 to 0.025 in. and the other in increments of 0.5 in. Provisions have been made for up to 11 passes which was considered adequate for this type of mill.

The roll positioning equipment also provides signals to the side guard and edger adjustment drives which insures coordinated operation of these drives for even and odd passes.

The time proved analog type of positioning system used employs a synchronous-tie transmitter which is geared to the screwdown drive and a corresponding synchronous-tie receiver which drives a mechanical differential assembly which carries two position control rheostats. The schedule selection panel is electrically connected to these rheostats and a simple error detection system provides signals to the adjustable voltage controller for the screwdown motor so that accurate position control is obtained in a minimum of time. Use of a rotating cam type of switch insures extreme positional accuracy and permits simple adjustments for system variables and deliberate overshoot.

All components of the positioning system are rugged,

mill type equipment chosen for long dependable life. Provisions have been made for manual operation at any time and push buttons have been provided for return to automatic control at any point in the program cycle.

Consideration was given to the possibility of tying these controls into a more completely automated system at a future date should this ever be desired. For example, automatic mill and edger reversal control can be added as supplementary control equipment. These additional features can be incorporated in steps as desired without significant modification of the existing control equipment. The important considerations in the design of such equipment are ease of installation, dependable service, and simplicity of maintenance.

A. F. Kenyon: Early plans contemplated a conventional two-high reversing roughing mill, however, it was finally determined to make the roughing mill four-high 36 in. and 54 in. × 58 in., to enable using slightly smaller diameter working rolls and assure the stiffness and rigidity necessary to make heavy reductions on stainless and similar hard alloy steel slabs. The 7000-hp, 40/100-rpm, 2,525,000 lb-ft maximum torque capacity reversing motor drive provides essentially the same turning force on the 36 in. diam working rolls (but at slightly lower speed), as an 8000-hp, 40/100-rpm, 2,880,000 lb-ft maximum torque capacity drive such as has been used on other two-high mills with 40 to 44 in. diam rolls. The 7000-hp drive has proved ample in torque and speed for all schedules rolled.

The new mill was installed with the vertical edger arranged at the entry side of the mill, to enable edging the slab on the odd-numbered passes when the slab is passing from the edger toward the main mill. Fifteen months operation has indicated the desirability of edging the slab on all passes in the reversing mill, and equipment is now in manufacture to install a second vertical edger at the delivery side of the main mill, to edge the slab on the even-numbered passes. The two vertical rolls of each edger are driven together through 3.0435 to 1 ratio reduction and miter gearing by a 600-hp, 150/450-rpm motor. Since only one edger is loaded during any one pass, both 600-hp edger motors are supplied from the same 600-kw supply generator.

The paper and other discussions have emphasized the importance of draft compensation in the control for the reversing mill edger and tables. The present edger control includes a draft compensation rheostat on the operators' control benchboard working into the edger generator voltage regulator circuit to reduce the edger generator voltage and edger speed and thus compensate for main mill draft corresponding to the setting of the rheostat. This adjustment has functioned very well and mill operation is good when the rheostat is set to the position corresponding to the actual draft being taken on any particular pass. However, on a five or seven-pass schedule, the draft may vary from 30 to 40 per cent on some early passes to 10 to 12 per cent on the last pass, and an average setting of the draft compensation rheostat does not give good mill operation over this range of reductions. Plans are under way to provide edger draft compensation adjustment for each pass of a schedule, to be automatically selected from the programmed screwdown control, to assure more nearly optimum mill operation at all times.

Rolling schedules in the five-stand continuous finishing mill range all the way from the rolling of 1 in. thick by 37 in. wide silicon steel bar to 0.068 in. thick finished strip at 1800 fpm with reductions of 30 to 50 per cent per pass; to the rolling of 0.500 in. thick by 51½ in. wide stainless steel bar to 0.125 in. thick finished strip at 1120 fpm and with reductions of only 10.7 to 36.0 per cent per pass. The accompanying speed diagram (Figure 16) shows the base speeds and maximum speeds available on each finishing stand with the drives as tabulated in the authors' Table VII; which also shows the speeds required for the above-mentioned extreme schedules. It is seen that with the heavy reductions taken when rolling soft silicon steel strip, stand No. 1 must operate below rated base speed even with 1800-fpm final delivery speed; while with the light reductions taken when rolling hard stainless steel strip stand No. 1 operates at considerably weakened field even with low 1120-fpm final delivery speed and at almost maximum speed when rolling narrower stainless steel strip. With the individual generator power supply for each finishing stand motor, speeds are continuously adjustable down to 60 per cent of base speed, to provide the wide operating speed ranges to enable rolling all grades of steel. With rectifier power supply it would be necessary to provide tap-changing-under-load to enable such continuous speed adjustment.

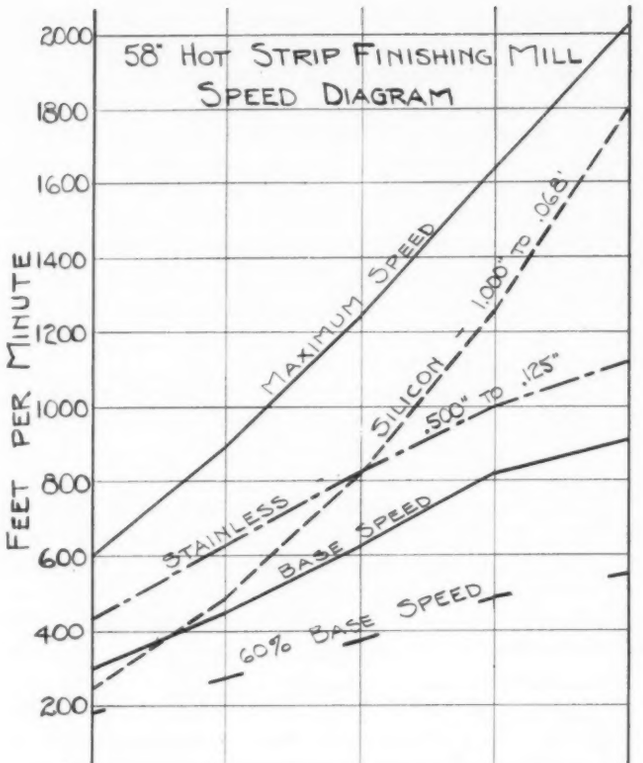


Figure 16 — Curves show speeds available for rolling various steels.

Present hot strip mill drive practice is to employ high gain quick response motor speed regulators to hold the motors in fixed speed relation, and thus minimize gage variations through the length of the strip, and tail-end thickness buildup. The Butler mill was engineered in 1955, before the advent of speed regulating control, however, the stand drive motors are

designed to have minimum practicable impact speed drop, 4 to 5.5 per cent at base speed and 3.25 to 4 per cent at weakened field speed, and are adjusted for about 3 to 4 per cent steady-state regulation. The individual stand power supply generators are designed for about 2.5 to 1 slope ratio, and are controlled by magnetic amplifier voltage regulators and interposed forcing exciters to provide a high gain quick response regulating system and maintain good transient and steady-state speed correspondence. The generator voltage regulators include an auxiliary IR compensation bias circuit with potentiometer rheostat adjustment over the range from about 2 per cent voltage rise to 4 per cent voltage droop to permit the operators to adjust the "stiffness" of the mill speeds. This method of stand regulation has proved quite satisfactory, and gage variation from head to tail end is within acceptable limits.

A. L. Lind: Finishing mill runout tables, the country over, are quite similar. The table rolls are nickel cast iron shells with a 300-Brinell surface hardness. They are mounted on a through shaft and connected to individual 3-hp, d-c motors through an 18 in. long floating shaft. The rolls are mounted on separate bases from the motors. This arrangement sets the motors back away from water spray and heat.

The two downcoilers are the expanding rotating mandrel type with retractable blocking rolls. The operation of these coilers is quite simple, yet there is a well-patterned system of operation and control for proper strip coiling that has been changed very little since the first installation of a coiler of this style back in 1938. These coilers, properly operated and maintained, will produce straight-side tightly-wrapped hot strip coils. Without going into great detail, the following explains briefly some of the operating features of the coilers.

The finishing mill delivery speed is the key to the proper speed setups of the three sections of runout tables, the coiler pinch rolls, mandrel and blocker rolls. As the delivery speed of the mill varies in accordance with gage and product being rolled, by the temperature of the steel and for other metallurgical reasons, the coiler speed must vary accordingly. A pilot generator attached to the drive motor of the last finishing stand provides a signal to which the coiler speeds are synchronized to the last finishing stand speed.

The blocker roll motors are driven from the same generator that supplies the mandrel motor. The field resistance of these motors and the mandrel motor is set in the control room so that the blocker roll peripheral speed and the mandrel surface speed exceed by about 5 per cent the peripheral speed of the pinch rolls. The pinch rolls have a preset peripheral speed 5 per cent greater than the last finishing mill speed.

As soon as the lead end of the strip is tight on the mandrel, the mandrel drops in surface speed to the strip speed. As the coil builds up on the mandrel, the speed drops further. This is accomplished automatically and electrically through a current limiting device which is preset by the operator. For light gage narrow coils the current limit should be set at a lower value than when coiling wide heavy gages.

The blocker roll assemblies move in and out radially to the mandrel actuated by air cylinders. Their purpose is to direct the lead end of the strip around the mandrel. As soon as the strip is tight on the mandrel and a current load is indicated on the mandrel ammeter, they are of no further aid to coiling and they should be moved to their "out" position. They are moved towards their "in" position on the final wraps to complete the coil.

If the strip is still in the last finishing stand and in the coiler at the same time, the mandrel will pull tension against the last finishing stand. As soon as the strip leaves the last finishing stand, the pinch roll ammeter will indicate a generating position indicating that the mandrel is now pulling tension against the pinch rolls instead of against the last finishing stand. In this manner coils produced are tightly wound and have straight sides. The surface of the strip is not scratched or marked since it has been coiled without contact with the blocker rolls.

C. F. Coburn: Uniform heating is necessary if the end-product is to be of uniform gage and top quality throughout. In most of these slab heaters there are skid marks to be taken out on the soak hearth. Then as the slabs reach the drop out skids there is another factor to be considered. Usually there are water-cooled drop-out skids on the slope of these end discharge furnaces to absorb the pounding from the slabs as they go over the break point. When the leading edge of the next slab to be discharged rests even briefly on this break point or extends out over it, as frequently happens when running various widths of slabs, there is a definite tendency to put new cold spots in this leading edge of the slab due to the black body radiation from these water-cooled skids.

On the furnaces at Butler the drop-out skids are cast of a high alloy, each in two sections down the slope. This makes a little more costly installation but we believe the savings in fuel and water plus the elimination of these skid marks more than justify the use of the alloy at this location.

On these furnaces these skids were put just about in line with the hearth skids. It was later found expedient to install additional skids between the original ones. The reasons for this was that many wide slabs are also thin. As they were pushed over the break point they would come down on the skids with sufficient force to give the slabs something of a "scalloped" effect. The additional skids eliminated this difficulty.

Originally there were alloy skids in the soak hearth also. However, the soak hearths on most billet and slab heating furnaces must contend with scale, and the highest temperatures of any point in the furnaces. These at Butler were no exception. The expensive high alloy gave very little more service than a much cheaper chrome iron or even plain carbon steel billets. Consequently the alloy skids have proved to be impractical on these furnaces and are gradually being replaced.

Those who have or operate slab or billet furnaces in plants, have undoubtedly been faced with high maintenance on the soak hearth for the reasons mentioned above, as well as several others such as the drooping ends of billets dragging onto the hearth, gouging from shear cuts, etc.

The hearths on these three furnaces originally had a 4½-in. top course of high alumina brick. This soon wore down and after about 2 in. had eroded, a 2-in. course of

rammed material was put over the remainder of the brick.

This worked rather well from an abrasive standpoint but, build ups occur on these hearths. There are several ways of removing this build-up. The one most commonly used is to run what is called a "plow" through the furnace periodically. When they tried to clean the hearths on these furnaces they found it impossible to separate the build-up from the rammed material and had to eventually clean down to the brick.

The next experiment was to remove the remainder of the top course of brick and replace it with 4 in. of rammed material and top it with ½ in. of chrome ore. It was believed that this would furnish a cleavage point between the rammed portion and the rest. This did not work either.

The new hearths now have about 4 in. of first quality firebrick covered with as thin coating of rammed material as practical. When hearth cleaning time comes the top coating will be considered expendable.

Clifford Elms: Considerable study and careful planning was given this project by Armco engineers and the mill builder, and a great amount of preliminary work was necessary before finalizing the layout or the mill equipment.

As stated, it was necessary to move the wheel shop and to lengthen the existing building to house the new mill, and while this program was in progress the old mill had to operate. This is quite different than building a new mill on a clean site. The job was made more difficult when we consider that the mill building was surrounded with equipment that must be kept in operation. ▲

Available Translations

As a service to readers of the *Iron and Steel Engineer* a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those of primary interest to the American steel plant operator. The papers may be obtained from the British Iron and Steel Industry Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England. All correspondence concerning price, ordering, and so forth should be directed to that address.

1460 Petit, J.: "The Fabrication of Large Diameter Welded Tubes at the Sedan Factory of the Société Lorraine-Escaut," *Techn. Moderne*, 1959, Apr. pp. 197–206. (List of contents: General characteristics. Production schedule, description of the chain of production. Preparation. Shaping Choice of process. Description of the twin arc submerged arc welding technique. Principle of the process. Welding the two electrodes. Principle of the twin arc process. Welding installations—general. Description of an external welding machine. External welding operation. Electrical equipment for each external welding machine. External welding process. Description of the internal welding machine. Internal welding procedure. Internal welding apparatus. Finishing. Welding control.)

1440 Guthmann, K.: "Measuring the Dust Content in Industrial Gases and in the Air—Measurements of Dust on the Ground," *Stahl u. Eisen*, 1959, Aug. 6, pp. 1129–1141. (Author's summary: The most important dust measuring instruments for investigating the problems of air purification and for its control are described. Reports on years of experience of dust content measurements in industrial gases and in the atmosphere and of determination of particle number in gases or air as well as on new experiences with dust deposit measuring instruments.)

1507 Pejcock, O., & J. Kuznik: "The Surfacing of Pilger Rolls of Rolling Mills," *Hutnicke Listy* (Prague), 1959 (2), pp. 173–184. A review is given of methods of surfacing Pilger rolls and their use outside Czechoslovakia. The use of hand surfacing of the rolls on the large and small Mannesmann tube rolling mills at the Vitkovic Iron and Steel Works is being developed. The results are given of experimental surfacing of rolls in low-alloy and carbon steels. An investigation is made of the influence of the chemical composition of the Ni-Cr surfacing materials and the welding technique on the pitting of surfaced Pilger rolls, and of the method of depositing the surfacing beads and the upper surfacing layers. The present techniques at the Vitkovic Works are described and economic advantages are shown. A marked increase was obtained in the wear resistance and working life of the rolls by comparison with ordinary unsurfaced rolls. The C content of the surfacing metal should not exceed 0.6 per cent; higher contents do not increase wear resistance, but only lower the notch impact strength, with resultant pitting of the rolls. As a result of the surfacing now carried out, roll costs have fallen by 48 per cent, and the train yield has increased by 1.1 per cent due to the time saved in roll changing.

1485 Ewe, K.: "Measuring and Control Plant at the Experimental Converter of Phoenix Rheinrohr at Duisburg Ruhrort," *Regelungstechnik*, 1959, July, pp. 248–253. The converter uses the PL-process in which P removal is accelerated and in the later stages the converter is tilted and surface blown. Gas flow, outlet gas analysis and particularly control of oxygen is described. Abstract preprinted from JISI.

1555 Weber, K.-H.: "Ring Rolling and the Construction of Ring Mills" (with Discussion), *Stahl u. Eisen*, 1959, December 24, pp. 1912–1923. The use of bars or specially cast ingots for rings is discussed, and a rough experiment to indicate the metal flow during ring rolling is described. After some notes on rolls and drive motors various types of ring mills for roughing and finishing, including some automatic ones, are described. In the discussion E. F. Dick describes an experiment from which he drew different conclusions about metal flow from those of the author. Translator's abstract.

effects of rolled steel requirements and raw materials supply on The American And German Steel Industries

by DR.-ING. ERICH KEMNA, Vice President, DEMAG Aktiengesellschaft Duisburg, Germany

THE differences in rolled steel requirements and raw material supplies have led the steel industries of Germany and the United States to develop along rather different lines. In a free market no industry can afford to live in splendid isolation, in its own little ivory tower. Its sole justification for existence is to process raw materials to meet the requirements of its customers.

The two factors—consumer requirements and raw material supplies—are the key to the understanding of any industry. How do they differ in the United States and Germany?

First are some basic facts which greatly influence the steel requirements: The population of the United States is 3.3 times that of the German Federal Republic, but in an area which is 32 times larger than that of Germany. In other words, the density of population in the Federal Republic is 9.5 times that in the United States! This then is the first impression if an American takes his car to Europe; he can hardly drive a few miles without touching another city or another village.

The larger number of products and specifications, two types of basic steel, mean that basic steel products in Germany require twice as many manhours to produce as in the United States . . . . the smaller geographical area means less basic demand . . . . raw materials are more costly . . . . cheaper labor rates make it economic to use more manhours in manufacture and engineering if it will save material on the higher cost end products.

What have these figures to do with steel? Because of the greater density of population there is much less railroad track in little over-populated Germany than in the United States. In fact, per capita, one finds in Germany not more than one third the railroad track and only one half the number of railroad freight cars!

No wonder then that this important steel consumer alone uses much less steel both in absolute figures and per head of population.

Pipelines for gas and oil are another interesting example. Although the use of pipelines is still in its infancy on the European continent, there is no doubt that the length of pipelines will never reach the mileage in the United States. In fact, on account of Germany's smaller area and greater density of population, the mileage will be only a fraction of what Americans are accustomed to in their country.

Another interesting factor which influences steel consumption and which is generally overlooked is that for a particular task, a smaller or larger quantity of raw material, in our case steel, may be used.

The automobile is a striking example: A German car because of the high taxes on fuel, must do more miles to the gallon. Furthermore, high taxes are imposed in Germany on the cars themselves, and they are imposed according to the cubic capacity of the engine. All this encourages the use of small cars with high-speed engines. Moreover, not all of the roads are "Autobahnen." In fact they are generally narrow, winding and overcrowded. Just think of the figures of density of population. These are the reasons why Germans prefer smaller cars. Consequently, in the United States an automobile weighs almost twice as much as an average German car. One can assume that this percentage of weight also applies to the quantity of steel used. That means that even if the same number of automobiles were purchased per head of population, the corresponding steel consumption in Germany would

only be about half of that in the United States. Thus tax laws and road systems influence steel consumption.

In many other fields too, steel consumption for a specific job is larger in the United States than in Germany. This is not a question of efficiency but rather the result of economic factors.

If the cost of steel is expressed in terms of manhours it can be said that for the price of one ton of steel in Germany one can buy four times as many manhours as in the United States.

To make this important economic factor clear, note that to build a fabricated steel structure, one uses steel and manpower. For the price of a certain quantity of steel one can buy four times as many manhours in Germany as in the United States.

Its consequence is that in order to save one ton of steel, Germans can afford to expend roughly 70 to 80 manhours, whereas the United States for the same purpose cannot expend more than one quarter of this figure, or about 20 manhours. It is, therefore, not surprising that in fabricating steel Americans save on manhours and use more steel while Germans save on steel and expend more on fabrication costs.

This factor is even reflected in codes: American codes, for example, permit punching of rivet holes. In Germany rivet holes must as a rule be drilled. Drilling requires more manhours than punching, but the permissible rivet load is higher and results, therefore, in less heavy constructions.

This possibility of spending more manhours is not restricted to the shop but includes engineering in the drawing office as well. Thus, in order to save steel, Germans can afford to spend more manhours on engineering. Therefore, Germans are accustomed to making very exhaustive calculations in our drawing offices.

As a rule, these exhaustive calculations lead to a greater variety of sections or plate thicknesses in an average German specification than is usual in the United States. As a result, orders for rolled steel placed by German manufacturers involve not only smaller quantities of steel but normally more items per ton than in the United States. Steelmen can realize what burden this imposes on both steel manufacturers and users.

It bears repetition that all this results from the difference in the ratio between steel prices and labor costs.

The extent of weight savings can be seen from the road bridges across German rivers. These bridges are now built with little more than half the quantity of steel used before the war. Unfortunately the price has not been slashed by half also.

Let us emphasize that it is only this ratio which is responsible for the generally lighter weight of German steel constructions and not that American engineers are less daring than engineers in Germany. One can see this every day in American designs, for instance in airplanes, where light weight is imperative. But in steel construction, simple economic reasons require Germans to save steel. It is remarkable to what extent our engineers learned to save on steel and simultaneously improve durability as well as quality.

One question one may quite rightly ask is with labor costs being what they are, why is German steel not cheaper than American.

A few reasons are that smaller quantities in a greater variety at specifications are used. As a result in Germany each ton of steel produced requires almost twice as many manhours. (This ratio applies to basic steel products and does not include fabrication.)

There are some additional reasons why steel is relatively expensive in Germany, and they are on the raw material side.

For instance, metallurgical coal is found in plenty in the Ruhr area. It has always been the basis of the German steel industry. But, due to the much less favorable geological conditions, coal output is less than two tons per manshift in the Ruhr, whereas in the States it is at least 10 tons. In other words, coal-mining in the Ruhr requires five times more manhours. This and the high capital investment for the deep shafts make German coal much more expensive. In fact, coal costs $15 per ton ex pit in the Ruhr as compared with roughly $6 per ton ex pit in the States. This means that German steel plants pay 2.5 times more for their coal than American. Imagine what a great influence this fact alone has on steel prices.

For many years Germany as well as other European countries suffered from a coal shortage which was partly covered by imports from the United States. In the past years, Germany and Europe underwent the same rapid changes in energy supply as in America. Oil rushed in as a competitor, forcing the whole of Europe to cut back coal production.

Fortunately, there is practically no unemployment in Germany at the moment. Therefore, displaced miners will be easily absorbed by other industries.

This briefly is the background to the controversy existing about imported coal, imported oil and the mining industry. After all, this industry cannot be held responsible for the difficult geological conditions found in the Ruhr, and one will appreciate that there are enough important reasons why Germans should not wish its mining industry to run down.

This does not mean that imports of American coal will be brought to a standstill, because there are enough customers, especially on the coast, who always lived on imported coal. Unfortunately, a certain cutback in the import of coal is unavoidable because of the increasing imports of oil.

The ores, principally from Sweden and the Lorraine, are of high phosphorous content. Formerly, the German steel industry depended almost solely on these sources. Therefore 40 per cent of the steel production now is still made by the basic bessemer process, which Americans practically never use because their ores are almost exclusively poor in phosphorous. As a result, American standard steel has a low nitrogen content and is, therefore, equally suitable for welding or riveting.

German basic bessemer steel, because of its high nitrogen content, cannot be used for complicated welded structures. Hence, German steelmakers and users have to cope day by day with two different types of steel of the same standard tensile strength, namely, basic bessemer and open-hearth, whereas Americans have essentially one type of steel which is equally suitable for both purposes. Just imagine the additional burden this imposes on both the manufacturers and users. Incidentally, this burden is another reason why

the manufacture of steel requires more manhours in Germany.

It is not surprising that experiments have been conducted for years to obtain, by oxygen blowing, basic bessemer steel of a quality equal to that of open hearth. Fortunately, these experiments have been largely successful so that basic bessemer steel similar in quality to open hearth is expected to be produced to an ever-growing extent. Competent steelmen believe that conventional basic bessemer steel will stay in Europe for many purposes for which it has real advantages both in price and quality. But they believe that it will be gradually supplanted by oxygen-enriched converter steel for purposes for which open-hearth steel is at present indispensable.

Of a great influence on the price of German steel is also the fact that capital has been very expensive for many decades. In the years immediately following the war, the job of rebuilding shattered factories and the steel industry swallowed up gigantic capital sums. This created a great capital shortage and made capital much more expensive than in America. Many investments which paid off in America therefore would not have worked in Germany. In particular, we had to forego fundamental changes in works layout which surely would have had a number of advantages. This is still another reason why in manufacturing steel in the Ruhr it is economic to use more manpower than in your country.

The emergence of the common market now confronts Germans with a new factor of vital importance. Just what its consequences will be is hard to predict, but there is little doubt that the common market represents a new quantity in the equation which the German steel industry must solve in order to maintain its economic balance.

It is no wonder that all the different conditions have also led to different requirements with respect to plant equipment design. It is illuminating, for instance, that the wide use of basic bessemer steel has resulted in much engineering work being devoted to the improvement of the converter plant and process.

Because German casting methods are different, the stripper cranes, for instance, are always equipped with rotatable tongs and are used for both stripping and ingot handling.

Rolling mills must be capable of changing over quickly and easily from one section or thickness to another because rolling schedules are shorter and more diversified.

Just as American engineers have developed very efficient facilities for the unloading of Great Lakes ore carriers, European engineers, due to dependence on overseas ore supplies, have developed most efficient unloaders for oceangoing vessels. Evidence of this is even to be seen in America in the ore unloading facility which our company built at Newport News, Va.

Thus, even the equipment manufacturers of the German steel industry had to go quite a different path from that taken in America, and equipment engineers have been educated for many decades to cope with rather individual requests in a very flexible way.

Now a few words about organization and production figures. At the beginning of the second World War, there was one concern, the Vereinigte Stahlwerke, which produced 39 per cent of the total German ingot steel and thus was number one on the market. The next five concerns, led by Krupp with 10.5 per cent, produced 37 per cent of the total German ingot steel production. The remaining 24 per cent was produced by many smaller plants.

All these plants together had a total production of 19,700,000 net tons of ingot steel in 1938.

The former German steel combines were dissolved after the war. In recent years individual groups of works have again been combined into larger units. Today there are ten important groups which in 1957 produced 27,000,000 tons of ingot steel. Thus the production in the area covered at present by the German Federal Republic, increased from 1938 to 1957 by 40 per cent. American steel output in 1957 was, of course, much bigger: 112,000,000 tons, or four times more.

If one deducts direct exports from both figures and adds the imports of steel, one gets per head of population, a home consumption in America of 1250 lb as compared with 860 lb in Germany. Germany thus comes nearer to the American consumption figure than most people expect. The reason is that in this little overcrowded country of Germany whose population grew since the war by 30 per cent from 40 to 52,000,000 inhabitants, must export a large proportion of its manufactured goods, as a matter of survival.

SUMMARY

The conditions under which the respective steel industries have to work differ. Due to Germany's greater density of population, important steel consumers, such as the railroads, consume less steel per head of population than is the case in America. Also, the use of steel for a specific job is often less in Germany than in the United States. The decisive reason behind this is the completely different relationship between the cost of steel and labor costs—including engineering work. The necessity of economizing in the use of raw materials has brought about a greater degree of subdivision into dimensions and qualities for a given job.

This latter fact is aggravated by the necessity of using phosphorous-bearing ores for making a steel which for many purposes is not suitable, so that German steel producers and users are constantly coping with two types of standard steel, namely, basic bessemer and open-hearth. Oxygen-blown steels, possessing properties analogous to those of open-hearth, have great prospects in the future. Historical developments and the high costs of capital, occasioned by the chronic capital shortage, especially after World War II, have left deep marks on iron and steel plants. No wonder, that the equippers of German steel industry often had to go different ways from their American counterparts.

All these factors influence each other, creating an economic balance which constantly changes. Thus, increasing wages and the common market may form a new picture of the German steel industry in the future.

Finally, steel production in Germany increased by about 40 per cent since 1938, and that due to indirect export, the steel consumption per head of population is not so much smaller in Germany than one might have expected.

Discussion

PRESENTED BY

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William T. Hogan, S. J.: This paper is particularly interesting at this time since we in the United States have been very much concerned over the matter of steel imports. In fact, it is one of the prime factors that has caused the steel industry to take the stand in the negotiations against wage increases that might be followed by price increases. Further, there has been a great deal of discussion of the fact that the United States, because of increased costs, is pricing itself out of some foreign markets.

In view of this, we would like to make a few remarks on the import situation, particularly in reference to the German steel industry. The import problem should not be exaggerated, and yet, it should not be minimized for it is not a hoax as some people have recently said. The problem is of extreme significance to some small steel companies in this country, as well as to some of the larger ones, especially in the divisions that manufacture common products such as barbed wire, wire fence, nails and concrete reinforcement bars.

In recent years we have had an increase in imports and our exports have declined considerably. In 1957 steel exports reached their peak when we shipped abroad some 5,200,000 tons of steel products. In the same year we imported 1,100,000 tons of steel products—virtually a five-to-one ratio in favor of exports. In 1958 we exported 2,700,000 tons of steel products and imported 1,700,000 tons, a ratio of less than two-to-one. That we dropped from a five-to-one to less than a two-to-one ratio of exports to imports is of significance. In the first nine months of 1959, we imported more than twice as much steel as we exported. Through the end of September, exports amounted to 1,773,000 tons, while imports reached the all time high of 3,770,000 tons. However, we should not make a final judgment on the 1959 figure since it is the result of a build-up of inventories in this country in anticipation of the steel strike and also stepped-up importing activity in anticipation of the same strike. Yet, if we take the 1957 and 1958 figures we see a marked trend toward closing the gap between imports and exports.

Because of these facts we are keenly interested in the developments of the Japanese and European steel industries, and Germany constitutes an important part of the European steel industry. We recognize the truly great advance that has been made in Germany since the close of World War II. At the end of the War there was virtually no steel production, yet in 1957, some twelve years later, Western Germany produced an all time record steel output of 27,000,000 net tons. There was a drop of nearly 2,000,000 tons in 1958 as the figure fell to 25,000,000 net tons. Thus we can see that the German steel industry has come a long way and has made tremendous progress.

One of the interesting items in Dr. Kemna's paper was the figures he cited on productivity, or manhours per ton of output. He stated that there were four times as many manhours involved in a ton of steel production in Germany as were needed in the United States. At another point in his paper, he said that each ton of steel produced represents twice as many manhours as a comparable ton produced in the United States. We imagine the discrepancy between these two figures is the result of including some factors in the first figure that were not included in the second.

The salient point is that there is a substantial difference between the manhours required for steel production in the United States and those needed in Germany. This is important when we consider the question of imports and exports because it provides us with the basic facts to get to the heart of the matter, i.e., comparative costs. The number of manhours plus the hourly wage rate give us the data to calculate comparable labor costs per ton of steel. We must recognize, however, that these comparisons may not be exact because of differences in accounting and production practices. Nevertheless, we do have rough comparisons between the labor cost figures in the German industry and those in the American steel industry. For the year 1957 they indicate a differential of ten dollars per ton in favor of Germany, i.e., their labor cost per ton of steel is ten dollars less than ours. This is certainly a significant figure.

In this framework we can look at the import-export situation that exists between ourselves and Germany. In 1958, Germany shipped 201,000 tons of steel products to the United States out of a total import tonnage of 1,700,000 tons. This was a slight increase over the 189,000 tons shipped here from Germany in 1957. On the other hand, we exported 132,000 tons to Germany in 1958; a figure slightly less than our 1957 shipments of 140,000 tons.

Interestingly enough, one of the products we export to Germany comes back to us in the form of finished goods. We send cold rolled sheets to the Germans since their cold rolled sheet capacity is not adequate to take care of their needs, and some of these sheets come back to us in the form of Volkswagons and other automobiles after a great deal of German labor has been expended on them.

In 1957 and 1958 most of the import tonnage that came to the United States was in the form of so-called, common products, i.e., wire rods, barbed wire, concrete reinforcement bars and nails. However, in late 1958, and particularly in 1959, a sizeable tonnage of specialized

products, such as pipe and tubing, came in. Germany is one of the principal sources of this product. Further, she is in competition with us on this product in the Middle East where she has shipped considerable quantities of pipe for oil industry operations.

Dr. Kemna mentioned one of the disadvantages the German steel industry labored under was the great variety of sections that had to be rolled. In the export trade, however, this can in reality be an advantage for it enables the Germans to supply a small amount of a particular section to someone in Latin America or Africa much more economically than we can.

In order to have an adequate understanding of the status of exports in German industry, two factors must be taken into account: first, Germany imports a considerable amount of raw materials, such as iron ore and coal; second, the German wage scale is roughly one-third of that paid to labor in the United States. Thus Germany is anxious to export manhours, and consequently, wishes to sell as much of a finished product as possible. Automobiles are one example. Another is machinery which she has offered to some steel companies in the United States on thirty-year terms. Therefore, future competition from Germany will tend to be in the form of manufactured products, and in the steel industry in the form of specialty products that require many manhours to produce. In this respect it is significant to note that Western Germany in the first nine months of 1959 shipped 138,000 tons of steel pipe and tubing to the United States. To be realistic, we can look for stiff competitition from the Germans in foreign markets, and to a certain extent, in our own domestic market.

Dr. Kemna made another interesting point in his paper which we trust he will elaborate. He mentioned that the per capita consumption of steel in Germany, omitting the direct exports, was 850 lb. I wonder if this figure also omitted the exports of finished goods, such as automobiles, machinery, etc. If it does not, then the per capita consumption would be much lower.

Dr. Kemna also told us that capital was expensive in Germany, and because of the difficulties in obtaining it immediately after the War, some of the plants were not laid out in the best possible manner. We have also been faced with the same difficulties here in the United States. We, too, can point to a number of instances where there was not sufficient capital to provide for an optimum plant layout, and thus many of our companies are producing under less than ideal conditions.

In connection with this same question, Dr. Kemna stated that capital is getting cheaper in Germany. That should mean that the German steel industry will be able to improve its physical plant. When this is done it is difficult to see why the German steel industry will not be able to attain productivity standards equal to ours. This is a fact of economic life that we must face, and it will tend to increase competition. Further, if Germany's wage rates remain at one third, or even one half of those paid in the United States, she will be able to produce steel substantially cheaper than we will.

The steel industry in the United States must meet this challenge by fully modernizing its plant and equipment and keeping production costs under control. The modernization of plant and equipment will require some change in the tax laws to allow us to write off the true cost of wear and tear on capital so that economically obsolete machinery can be replaced and productivity improved.

Dr.-Ing. Erich Kemna: It is correct that our paper mentions two different figures for manhours which may have caused some misunderstanding. In the first instance we stated that for the price of a certain quantity of steel a German manufacturer, say, of steel structures, can buy four times as many manhours as a manufacturer in America. The consequence of this is that in fabricated steel structures you save on manhours while we rather save on steel and expend more on fabrication costs. We have emphasized that this is bound to result in quite different principles of design.

In the second instance we stated that the *production* of one ton of steel in my country requires almost twice as many manhours as it does here. This and other reasons such as higher expenditure on coal and other raw materials are responsible for the manufacturing costs for steel in Germany being roughly the same as in the States despite lower labor costs. There is still another reason for the manufacturing costs of steel being roughly the same and that is productivity. We are afraid that our steel industry will never attain the productivity of yours. Even if we had the same per capita consumption and the same number of sections and plate thicknesses, the fact remains that you have a bigger population than we have and a greater demand. One must bear in mind that our biggest steel production units produce not more than 3,000,000 tons of steel annually.

Incidentally, another reason for our comparatively high production costs is shortage of capital, and its high cost. We wish we could offer our customers in technically young countries the same terms as your banks do. Our customers do not get more than six or seven year's deferred payment—not to mention higher interest rates—and thirty-year terms are unthinkable in our country. A comparison of these factors makes the shortage of capital in Germany obvious.

The figure for home consumption can be found in our statistics year book. It is computed on the following basis: Direct *exports* are *deducted* from and direct *imports added* to the annual steel production figures. All the figures are expressed in ingot tons so as to arrive at a common denominator. Thus the home consumption figures always *include* indirect exports of manufactured goods containing steel and do *not* include indirect imports.

Colonel Merle R. Thompson: Dr. Kemna provides, in his paper a useful, almost essential, background for any look at the steel industry in Western Germany. He sets forth clearly and simply many of the basic influences that cause divergence in the ways of the two countries. Most of the considerations cited tend to reduce the per capita requirements for steel in Germany below that in the U. S., yet Dr. Kemna reports a home consumption of steel per capita almost 70 per cent that in the U. S. German exports of products manufactured from steel help to make up for the lower domestic requirements for steel for other purposes.

Dr. Kemna points out effectively some of the influences of our lower labor costs in manhours per ton; these, it should be noted, are about in the order of one to two. However, our comparative hourly employment costs were in 1957, of the order of about three times those in Germany. Our actual employment costs in dol-

lars or marks per ton of steel would then be about one and a half times those in Germany. In any event, the number of manhours we can afford to expend to save a ton of steel depends on the total cost of the steel and the cost of the type manhours we propose to expend. While there is undoubtedly some edge in favor of Germany in this regard it probably does not exert too great an influence.

It is perhaps worth noting also that the production of 40 per cent of German steel by the bessemer process has another interesting effect. D. J. O. Brandt, Metallurgical Editor of Iron & Coal Trades Review, notes that this results in the availability of a much larger proportion of scrap for the 60 per cent produced in open hearths, and that modern open hearths are supremely well adapted to scrap melting. This helps to account for the approximately 50 per cent higher productivity of German open hearths and reduces to some extent the disadvantages of the bessemer production.

Dr.-Ing. Erich Kemna : There is nothing more difficult than comparing actual costs—particularly labor costs. We therefore tried to avoid doing so and only quoted comparative figures and manhours. For instance, the wages agreed with our unions give a false picture because actual average wages are higher. To find out how much higher they are one would have to go through the accounts of many a plant.

What Colonel Thompson said about scrap was quite right. The combination of oxygen-blown, perhaps even basic bessemer-converter plant and open-hearth furnace plant has the advantage that one can, depending on the price of scrap, produce either more open-hearth steel or more oxygen-blown converter steel. The extent to which scrap prices influence steel prices is well known. The combination mentioned would, therefore, lead to steadier scrap prices.

Kurt Schlesinger : One main factor for the difference in development of the steel industry in Germany and the U.S.A., is the output of coal and quality of available iron ore in Germany. As we were told, the output of Ruhr coal, for instance, is less than two tons per man shift in comparison with ten tons in the U.S.A.

Recent developments of the steel industry point to the fact that modern steel plants are located at "water's edge" where water transportation facilities are available. To mention two of these modern installations: The new Kloeckner Werke in Bremen, Germany and Breedband in Ijmuiden, Holland. Such plants are not dependent on high priced local raw materials, but are able to obtain coal as well as iron ore from the most advantageous sources, adding low cost water transportation. Some steel plants in Europe as well as in Japan depend entirely upon water transportation of raw materials.

Furthermore, in rolling steel, modern mill installations of the continuous type will reduce manhours per ton of steel produced.

Finally, with increased production at lower costs, a revision of steel standards in Germany might be necessary, eliminating some of the great variety of special sections which tend to reduce the production efficiency of any rolling mill plant.

Dr.-Ing. Erich Kemna : Kloeckner built a new plant in Bremen on the Weser and can unload direct from seagoing vessels. They can therefore obtain raw materials from the most advantageous sources and are furthermore in the center of an important industrial and shipbuilding area. But that huge concern could provide the funds for this great enterprise from its own resources chiefly from depreciations. It would not have been economic for Kloeckner to finance their new plant by loans because of the high cost of capital in Germany.

Emil Kern : When we look at records of the pounds of steel used per capita in a particular country, we often wonder what the implication is, whether this is a yardstick of industrialization in a country, or whether it is a yardstick of standard of living in a country. We use these figures often for various purposes. The thought that always occurred was this, what is the steel being put to and how many pounds of finished parts or products can we make out of one ton of ingots?

We have just heard from Dr. Kemna that they build their bridges today much lighter than they did before the War. He did not say they weighed only half as much; he said they only use half the steel they used before. Also, we do know that the automobiles are much lighter. Some of us have these cars. Apparently they make their ingot tons go farther. So, thinking in terms of use of steel rather than ingot production of steel is something on which we need more information.

Surely, some of the learned economists have given this some thought and have maybe come up with some correction factor that would adjust these per capita figures of various countries to reflect the different methods of engineering or manufacturing and other factors entering into this equation.

Maybe Dr. Kemna can tell us whether a ton of ingots in Germany may make 1.3 times as many finished products as a ton of ingots used in our country? If there is any data available on this subject, it would be of interest.

Dr.-Ing. Erich Kemna : We have no such figures available, and to develop an answer would require close study. ▲

There is a constant demand for copies of "The Modern Strip Mill" published by the Association of Iron and Steel Engineers.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Modernization of Steelton's 20-In. Mill

by R. M. WEIGLE,
Superintendent, Rolling Mills,
Bethlehem Steel Co.,
Steelton, Pa.

. . . . a new 28-in. mill and a new 3-zone furnace have improved quality and yield while permitting standardization of bloom sizes . . . .

ABOUT two years ago Bethlehem Steel Co. decided to modernize the 20-in. mill at their Steelton plant. This decision was based on the need to roll larger products, increase the tonnage rolled per month and produce a better end product.

The old mill installed in 1913 was a steam-driven mill. It consisted of three stands of 3-high rolls in line, served by two traveling tilting tables on each side of the mill. In 1929 the steam engine was removed and a 2000-hp electric motor installed. This mill had the advantage of being able to roll a large number of sections at relatively low roll cost. It is shown in Figure 1.

The mill was fed by two oil-fired, single-zone furnaces. The quality of heating was questionable at times and the maximum combined capacity of the two furnaces was 35 tons per hr. This limited the output of the mill on fast rolling orders. In addition, considerable manpower was required to handle the blooms in and out of the furnaces.

The modernized mill lay-out, as shown in Figure 2, consists of a new 3-zone heating furnace, a new 2-high reversing breakdown mill, two stands of the old 3-high mill, a new 2-high leader stand and a new 2-high finishing stand. At the discharge end of the hot-bed a new overhung-type roller straightener and a new shear are installed.

The new 3-zone heating furnace is oil fired, has a heating capacity of 70 tons per hr and is normally operated with two rows of blooms in the furnace. It is an end-charge and end-discharge furnace. Blooms are brought to the charging table over a pusher type transfer bed and positioned by means of a power-driven roller line. The two furnace pushers can be operated independently or locked together into one unit. This permits us to handle blooms ranging in length from 6 to 8 ft in two rows or 12 to 16 ft when

Figure 1 — The 20-in. mill was able to roll a large number of sections at a relatively low roll cost.

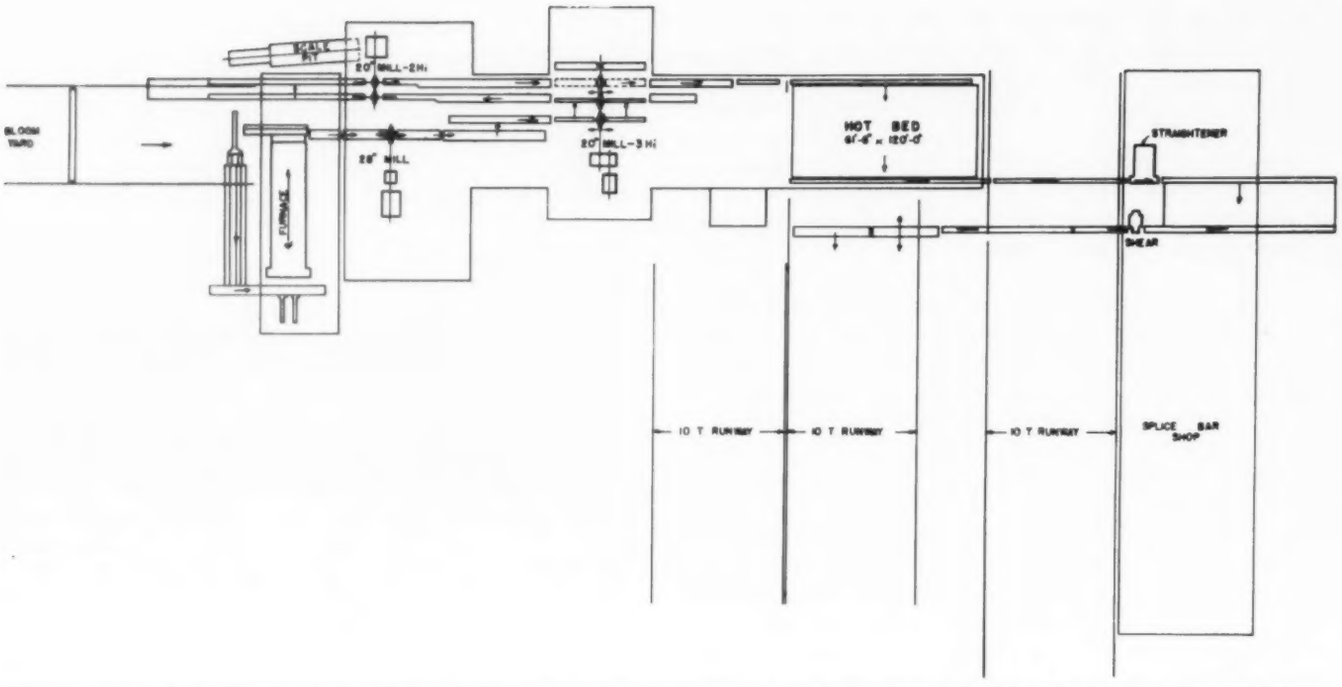


Figure 2 — The layout of the modernized mill shows the placement of the new 28-in. mill relative to the two old 3-high stands and the material flow pattern.

operating as a single row furnace.

The furnace was originally designed to handle blooms any size from 4 x 4-in. to 12 x 12-in. cross section. It was known that it would be quite difficult to stop the pushers accurately enough to push just one 4 x 4-in. billet off the knuckle at the discharge end, unless a man was looking in the door at this point and had the controller at his side. For reasons of safety and better heating practice, it was decided to install two television cameras at this location, one on each side of the furnace. The camera mounted at the left side of the furnace is shown in Figure 3. The pusher operator, while in his pulpit at the charging end, can observe the blooms as they are pushed over the knuckle at the discharge end. These cameras have been in operation since March, 1957. They work very satisfactorily and their maintenance has not been a problem.

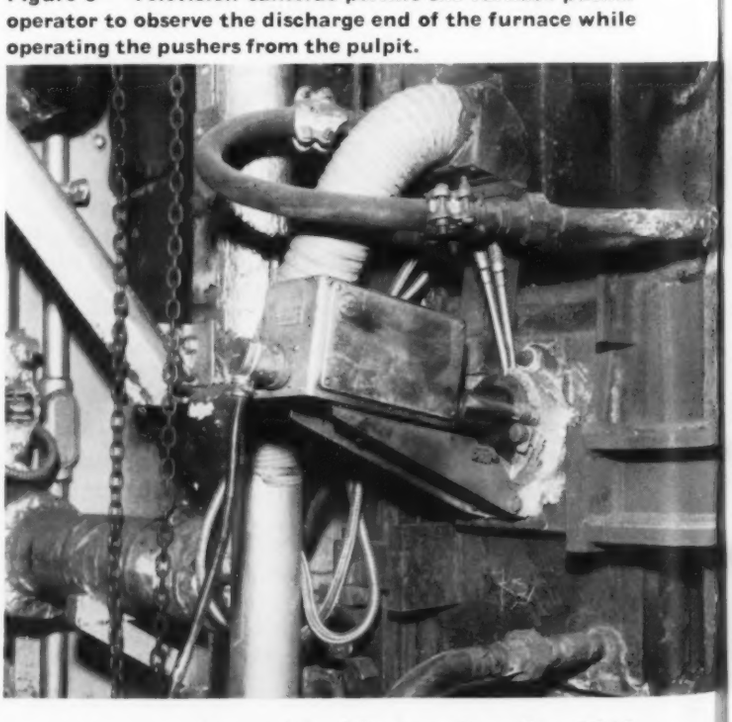
Since the installation of the 28-in. breakdown mill in September, 1958, the heating practice has changed a little. There is no longer any need to heat blooms smaller than 6 x 6-in. in cross section. There is also occasion to heat slabs as large as 30 x 6½ in.

The 28-in. breakdown mill is shown in Figure 4. This mill was installed in order to roll larger sections than was possible to roll in the past. The plant also standardizes on a few bloom sizes and breaking them down to fit the various sizes needed on the 20-in. mill. This eliminates passes on the 3-high mill and gives an increase in the tonnage rolled per hr. Surface quality, on products rolled from scarfed blooms, has improved since surface irregularities are removed by light passes and frequent turning before the bloom enters shape passes.

The mill itself is a 2-high reversing mill equipped with manipulators and side guards. It is driven by a 3000-hp, d-c reversing motor through a 28-in. pitch-diameter pinion stand. It differs from most other small blooming mills in its exceptionally wide window-plate opening of 43 in. which permits the use of high collar rolls for shape passes. In this connection the housing is also equipped to take a rest bar when rolling certain unequal sections. Rolls can be changed very quickly by means of a duplex roll-changing rig.

The screwdown is automatically controlled by means of a punched card which also operates the discharge table after the last pass has been completed. This card permits the use of a 30-pass layout which is more than ample for present needs. For mill operation the operator signals when he wants a bloom discharged from the furnace. This bloom automatically proceeds down the

Figure 3 — Television cameras permit the furnace pusher operator to observe the discharge end of the furnace while operating the pushers from the pulpit.



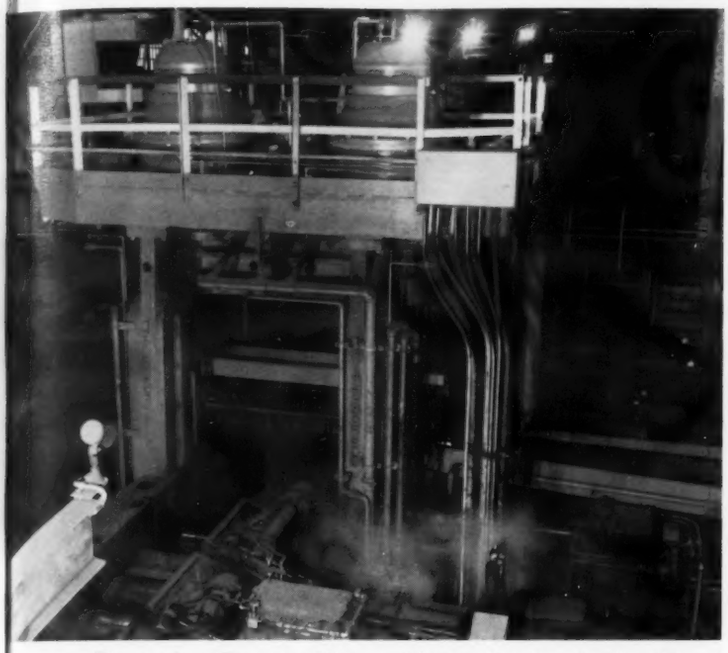


Figure 4 — The new 28-in. mill permits standardization of bloom sizes and elimination of passes on the 20-in. mill.

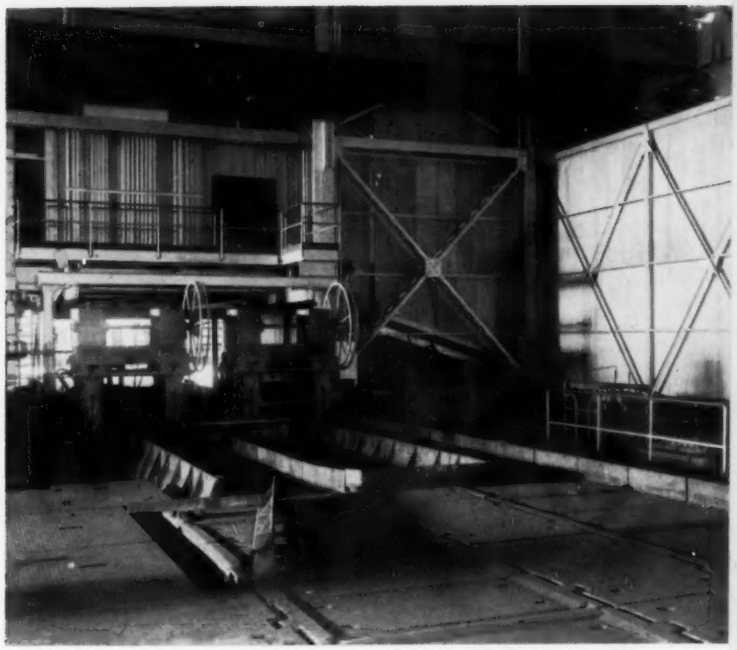


Figure 5 — Two new 20-in. stands were installed to permit higher finishing speeds and a higher final temperature.

roller line to the entry table at the mill. With the screwdown set for the first pass opening, the operator positions the bloom and runs it through the rolls. He then pushes a button for the next pass opening and immediately runs the bloom back through the rolls. He then turns it and positions it in front of the rolls until all passes have been completed.

All punch cards for screwdown settings are prepared under the supervision of the roll designer. Each card is given a number and shows the size of bloom before entering the mill and as it leaves the mill. He also prepares an explanatory card which is given the same number and which shows the bloom position for each pass and the roll opening inches. These cards are returned to the mill office at the completion of the rolling. Sometimes months may pass before that particular card is needed again.

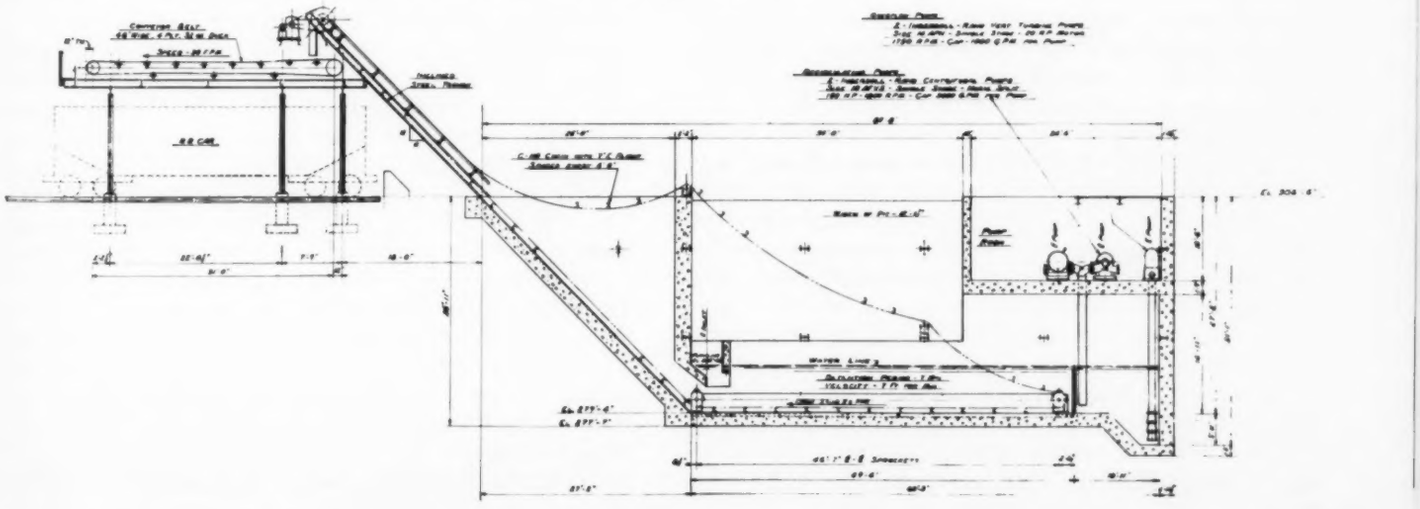
When the 28-in. breakdown mill was put into operation there was no one with any experience on this type of mill. The preset screwdown was of considerable help and incidentally, eliminated a lot of cobbles in getting the mill started.

The new leader and finishing stands are shown in Figure 5. These stands were installed to get a higher finishing speed. This increases production on the mill and permits finishing with a hotter bar.

The stands are driven by a 3000-hp synchronous motor through a 2-speed gear-reduction unit. Either 75 or 150-rpm can be secured on the output shaft by shifting a sliding yoke, inside the gear box, from a low-speed to a high-speed gear. The finishing stand is driven through a standard 22-in. pitch-diameter 2-high set of pinions. The leader stand is driven by a line shaft passing under the housings and connected to a 22-in. pitch-diameter 4-high pinion stand.

The main reduction unit also contains an inching drive. When it is necessary to change rolls, power is cut off the main drive motor and the inching unit is ener-

Figure 6 — The 20-in. mill is equipped with a modern scale disposal system.



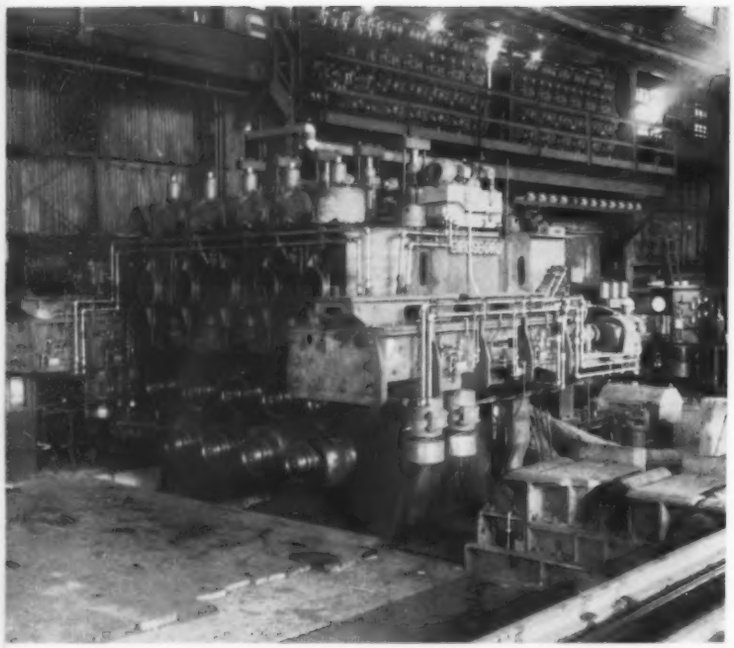


Figure 7 — Placement of the roller straightener at a distance from the hotbed allows easier servicing for roll changes.

gized by means of an air clutch. This drive operates the main gear reduction unit at an output speed of four rpm.

During normal rolling operations these two stands are operated at 150 rpm. However, on heavy sections it has been the practice to run at 75 rpm, which is fast enough to balance heating capacity. The slower speed also puts less shock on the mill.

The 20-in. mill is equipped with a modern scale-disposal system. Sluiceways are provided under the mill housings and tables to flush all mill scale to a settling basin outside the mill building. The basin is of sufficient length to provide time for settling the scale. A drag conveyor elevates the scale to a railroad car placed at the end of a conveyor. A section view showing the conveyor, pit and pump room is shown in Figure 6. Recirculating pumps of 3000-gpm capacity provide plenty of water for roll-cooling and scale-flushing purposes. In order to save floor space the pump room was placed above the water line in the scale pit itself.

A new roller straightener shown on Figure 7 was installed in the roller line from the hotbed. It was decided to install this machine approximately 75 ft from the hotbed to provide more room for roll changes and to eliminate safety hazards. It also permits disposition of all products which do not require straightening immediately after they leave the hotbed.

The new straightening machine is an overhung type which permits rapid roll changes. It is equipped with nine horizontal rolls and four vertical rolls. The top horizontal rolls, five in number, are individually adjustable up and down and in and out, the four bottom rolls are individually adjustable in and out. The four bottom and first two top roles are driven. The two vertical rolls on the entry side are driven and adjustable up and down and in and out; the two vertical rolls on the discharge side are adjustable in same manner but are not driven. All roll adjustments are made by remote control from push buttons.

The horizontal roll spindles are tapered and no keyways are used. The spindles are equipped with hydraulic connections. Rolls are pressed on hydraulically and removed by the oil-injection method.

A transfer bed is located at the discharge side of the roller straightener. This bed has two functions. First, it positions bars, two at a time, in front of the shears for proper shearing. Second, it provides some storage space for operation of the roller straightener if the shears are shut down for any reason.

The new shears are shown on Figure 8. It is designed to shear two bars at a time. Bars proceed to the shears on a roller line where they enter a pinch roller. After cropping they proceed automatically to the length stop where they are sheared to length, the stop raising and lowering automatically as soon as the sheared lengths clear the stop. During the shearing operation bars are clamped hydraulically to permit an accurate cut. After bars leave the shears they are inspected as they proceed up the roller line to the proper kick-off pockets, a distance of approximately 150 ft.

One of the outstanding features of this mill layout is its flexibility. In addition to using the complete layout it is possible to operate the 28-in. breakdown mill by itself. The old 3-high mill can be used in conjunction with the 28-in. breakdown stand, but without the new leader and finishing stands; or the 28-in. breakdown can be used with just the two new stands, by-passing the old mill completely. In this era of rapidly changing products, a flexible mill layout is very important.

Discussion

PRESENTED BY

E. C. PETERSON, Vice President, Rolling Mill Equipment Div., Birdsboro Corp., Birdsboro, Pa.

R. M. WEIGLE, Superintendent, Rolling Mills, Bethlehem Steel Co., Steelton, Pa.

E. C. Peterson: The 28-in. mill is of particular interest to us, since it was our privilege to collaborate in this installation. There are a few minor features of the mill that might be of interest. One is the arrangement for using the existing three 20-in. mill stands, at least temporarily, until the existing stock of rolls is used up. As we proceeded with analysis of the new installation, it developed that the stock of rolls in a specialty mill of this sort is an extremely valuable item. In fact, it bears a significant proportion to the cost of the entire mill installation, so a modification was agreed upon, in which the runout table from the new 20-in. finishing mill was made a movable extension to the tilting table tracks; thus the existing three stands can be left in position when rolls are available, and the new table is moved off to one side so the traveling tilting tables serve these three stands. Thus it is possible to use up the existing stock of rolls.

Mr. Weigle also mentioned the fact that the 20-in. mill can now produce bigger sections than before. Although the pitch diameter of the finishing mills has not been changed, the 28-in. mill is used to produce blanks

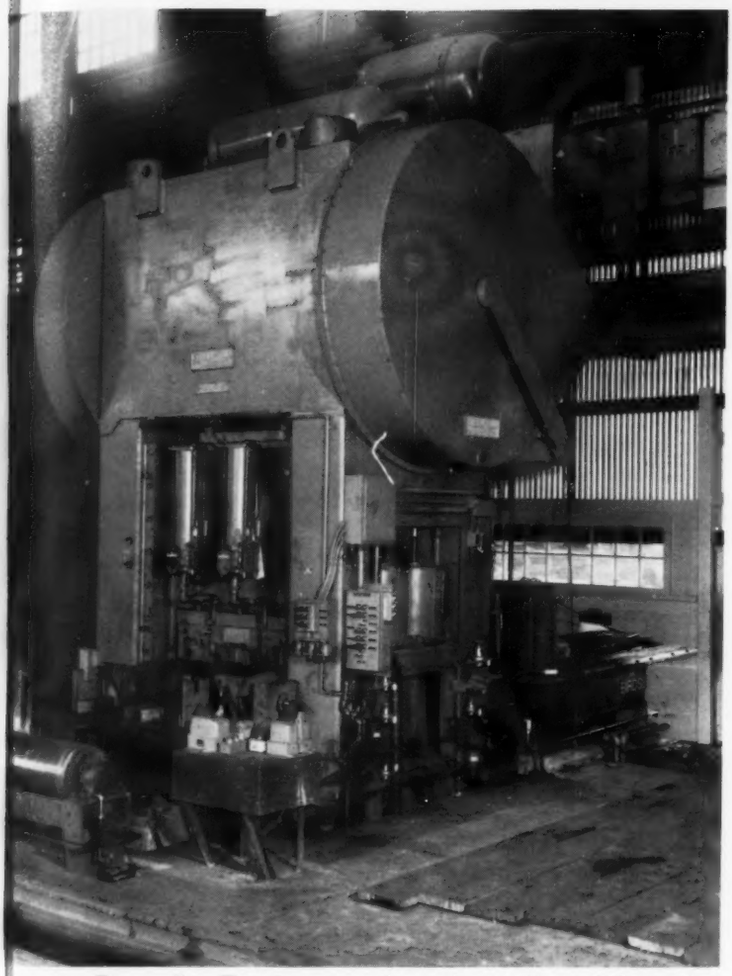


Figure 8 — Two bars are sheared at a time, being automatically cut to length while hydraulically clamped in position.

from larger blooms than could be originally handled on the 20-in. mill, and thus larger sections can be handled on the 20-in. finishing mills.

The 28-in. mill is also provided with an auxiliary turn up, so that billets or squares as far down as 3 × 3 in. can be produced with oval and square reductions. The leader and finishing stands are 2-high and the author mentioned that the mill produces a better section than it did originally. It is always a problem on any 3-high mill to adequately support the middle roll, for there just is not enough space between the necks to get a good support. By using separate 2-high leader and finisher stands, it is possible to get a more rigid mill, and thus to produce a more uniformly accurate section.

The author also mentioned that the transfer between the straightener runout table and shear approach table can act as a storage unit. We find that many operators believe that a transfer with a certain number of spaces on it gives surge capacity between the mill and the finishing end, but it is not actually so. If there are only a certain number of storage points and a bar must be taken off every time one is put on, there is no surge capacity at all. It is necessary to incorporate in a transfer, if surge capacity is desired, a feature similar to the one used at Steelton, whereby a cable and dog transfer arrangement feeds stock to an entire independent ducking dog mechanism. This mechanism then advances the entire stock of material to the shear approach table independently of the feed to it.

The ducking dog transfer has an adjustable stroke, so that within the confines of the space available, the stroke can be adjusted to get the maximum storage capacity that the width of the product being handled will permit.

There are a few points that we would like to ask the author to comment on, in view of his operating experience so far.

The scale pit incorporates a mechanical scale removal system. What kind of mechanical maintenance is required with regard to the mechanical components of the scale-removal conveyor? And does the constant movement of this mechanical conveyor adversely affect the clarity of the effluent from the system?

The straightener has the roll sleeves mounted on the spindles without keyways, and they are mounted and removed by the oil injection system. What operating experience has the author had with this new type of mounting?

The 28-in. mill was shown in one of the figures, showing that the side guards had extensions reaching between the housings. This was felt to be desirable because of the wide windows, which keep the side guards relatively far from the rolls. If this had not been done manipulation of the bars would have been more difficult. Of course the objection to the extension side guards is that they block off valuable roll body space.

We would like to ask, taking these two considerations one against the other, whether or not the author prefers the extensions?

R. M. Weigle: In connection with the scale pit, mechanical maintenance has been no problem. However, we are going to make one little change. The speed of the operating conveyor is two fpm, and on cleanup days (we generally clean up once a week at this mill), we experience some shear pin breakage. We are making plans to put a gear shift mechanism in the drive. So for normal operation with the mill working, the conveyor would be at the standard speed of two fpm, on clean-up days it would run four times as fast. We believe this will eliminate shear pin breakage.

As to constant movement affecting the clarity of water in the system, we have not experienced any difficulty from this source. The scale pit is 60 ft long and we have considerable time at the rate of 3000 gpm for the scale to settle out.

Mr. Peterson has asked concerning our experience with the new method of mounting rolls on the straightener. We were a little concerned about what would happen when we first put these rolls on, not that we thought this method would not do the job, but we were not sure how tight to press them on. We experimented with oil pressures, ranging up to 5000 psi. We finally ended up by using 3200 psi and have had no trouble at all with the rolls coming loose on the spindles.

As to side guard extensions, we feel they are quite important. The mill housings are designed so rest bars can be installed and we expect to use them when we get more complicated beam and blank sections. However, most sections can be rolled without any difficulty by means of the side guard extensions. It is our practice to allow three or more in. of roll material between the last pass and the end of the roll. These extensions easily fit into that space. ▲

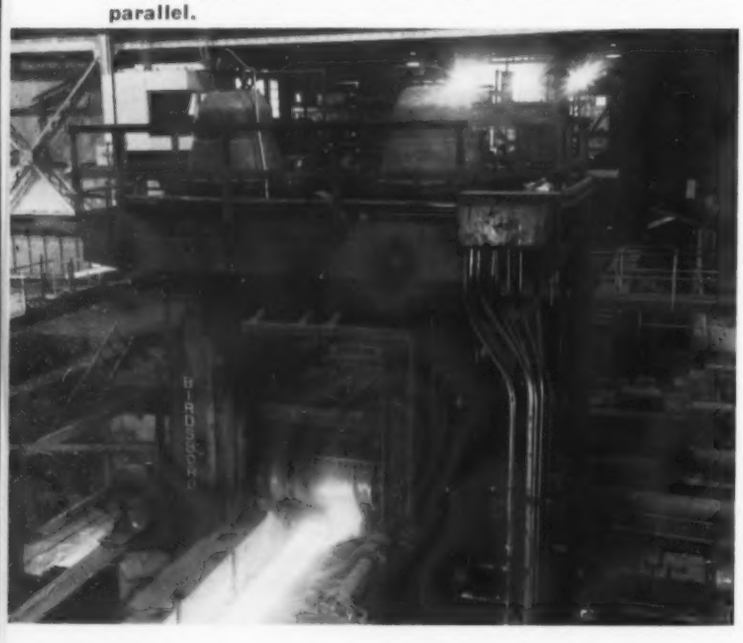
Automatic Preset

ON September 14, 1956, the management of Bethlehem Steel Co. approved an appropriation to rebuild its 20-in. merchant mill located at the Steelton plant. Among other things approved, at that time, were two additional mills; a 20-in. bar finishing mill and a 28-in. reversing blooming mill.

Since more stringent demands were being made to increase the uniformity of the blooms, training of men to operate these new mills, especially the 28-in. reversing mill, became a major consideration. Considerable discussion within the engineering, mill, and electrical departments followed, with regard to the sequence of operation of necessary electrical control, and where and how the various pilot devices should be located. The mill personnel decided that one operator should take the steel from the furnace, break it down in the 28-in. reversing mill and deliver it to the next mill, which is the existing 20-in. mill. It was agreed that one operator could perform these duties, but that if everything was to be operated manually, it would be necessary for him to perform on an average, approximately one manipulation every $1\frac{1}{2}$ sec over an eight-hour period. Given the responsibility of producing both quality and quantity, it was seen that this job would not be a very desirable one unless some of the more tedious operations could be made automatic. It was decided to begin the automation with the mill screwdown control. Also, the back mill and runout tables were to be made automatic on the last pass, at the discretion of the operator.

There was considerable discussion concerning the dependability of an automated system. Would the system be reasonably trouble free? How easy would it be to locate and make the necessary repairs if trouble should occur? The final decision was made to use a punched card programmed system, synchronous-tie receiver and transmitter, magnetic amplifier detectors, and a duplex, reversing-plugging, dynamic braking magnetic controller. It was thought that this combination of control would meet all of the requirements, be trouble free, and fairly simple to repair.

Figure 1 — The screws of the 28-in. mill are driven by two 50-hp, 550-rpm, AISE 610 mill type motors connected in parallel.



On the 7 to 3 shift, September 25, 1958, the first steel was rolled in the new 28-in. mill, and much to the satisfaction of all concerned the automatic preset screwdown control was one of the operations which functioned properly. It has continued to function to our satisfaction up to the present time, and is now considered to be quite successful.

The following will briefly describe the equipment and control system required to operate 28-in. mill screwdown drive (Figure 1). The screws are driven by two 50-hp, 230-volt, d-c, 550-rpm, compound-wound, frame 610 mill type motors, connected in parallel. Two size 16, series-wound, d-c magnetic brakes are used with these motors. A 2-hp synchronous-tie transmitter for the automatic control, and a 1-hp synchronous-tie transmitter for the screwdown indicator are geared to the screwdown. In the pulpit (see Figure 2), there is a 2-hp synchronous-tie receiver connected to the differential positioning drive, which consists of a differential gear assembly, one main 30-segment rheostat, one vernier 40-segment rheostat, a cam-type limit switch, and a 0.1-hp preset motor and worm drive. The card reader which accommodates a 9 x 5-in. plastic card, is also located in this area. On the right in Figure 3, located in the pulpit, is the 1-hp synchronous-tie receiver driving the screwdown indicator for manual operation. On the control desks, along with the other mill master controllers, are push buttons marked "operate," "return to No. 1," "reset," "set-up," "synrun," and a manual master for the screwdown drive, and a pass indicator unit consisting of two number indicating tubes. The 9 x 5-in. plastic card is divided into three sections (Figure 4). The left hand section of the card is used for main increment information 0 to 24 in., in increments of 2-in., the center section for vernier information, 0 to $1\frac{15}{16}$-in. in increments of $\frac{1}{16}$-in., and the right hand section is used for return to No. 1 position and auxiliary functions. Each column represents one increment and each row represents one pass.

A card placed in the card reader of the card programming system shown in Figure 5 is held by a movable carriage which passes it between a row of fixed contacts and a row of movable brush-type contacts. The brush-type contacts are divided into three sections, each section electrically common, and corresponding to the three sections of the card. The fixed contacts are connected to the segments of the rheostats. The card carriage holds the card between the fixed contacts above the card and the movable brush-type contacts which press against the underside of the card. Wherever holes are punched in any row on the card, the brush-

Screwdown Control on Steelton's 28-In. Mill

type contacts pass through the holes and make contact with the corresponding fixed contacts. By this means the brush-type contact block in each section is electrically connected to one of the fixed contacts of the main and vernier sections respectively. To protect the card reader and to make the operation just about foolproof, several important features are provided. First, to remove or insert a card in the machine, the carriage must be in position No. 1. There is a card locking device which inserts two tapered pins through locating holes in the card to correctly position the card on the carriage. The card locking device also operates snap switches to insure that the reader will not be energized, when a card is withdrawn, and that the brush-type contacts are lowered to prevent short circuiting the rheostat circuits and to allow free movement of the card. A sensing pin is mounted in the reader to detect the presence of a card. This pin mechanically prevents the operation of the locking device when no card is in the reader. The card sensing contacts are not used to make or break current carrying circuits at any time. Last but not least is a position 30 limit switch which will return the carriage to position No. 1 after completing an operation on row No. 30, in the event that a card is inserted having no hole punched in the "return to position No. 1 section."

by G. D. NICOLSON
Superintendent
Electrical Dept.
Bethlehem Steel Co.,
Steelton, Pa.

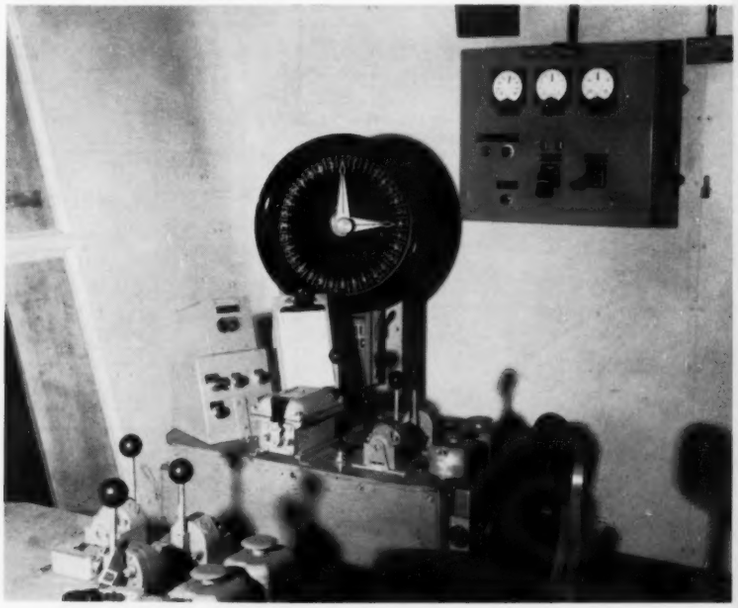
. . . . a high accuracy analog system reduces the number of manipulations to be performed by the operator but still permits accurate screwdown control . . .

The card puncher (see Figure 6) is a very simple and inexpensive device. It is kept in the mill office with a supply of unpunched cards. Opposite each pass number, on the left hand side, the total roll opening for each pass is the sum of the main and vernier increments. The return to No. 1 position under "R" on the right hand side of the card has to be punched after the last active pass, on the next pass number.

The control scheme makes use of seven magnetic am-

Figure 2 — The 28-in. mill is operated from a modern pulpit by one operator with an assist from the automatic preset screwdown control.

Figure 3 — The screwdown can be manually controlled if desired and during manual operation a 1-hp receiver drives the screwdown indicator.



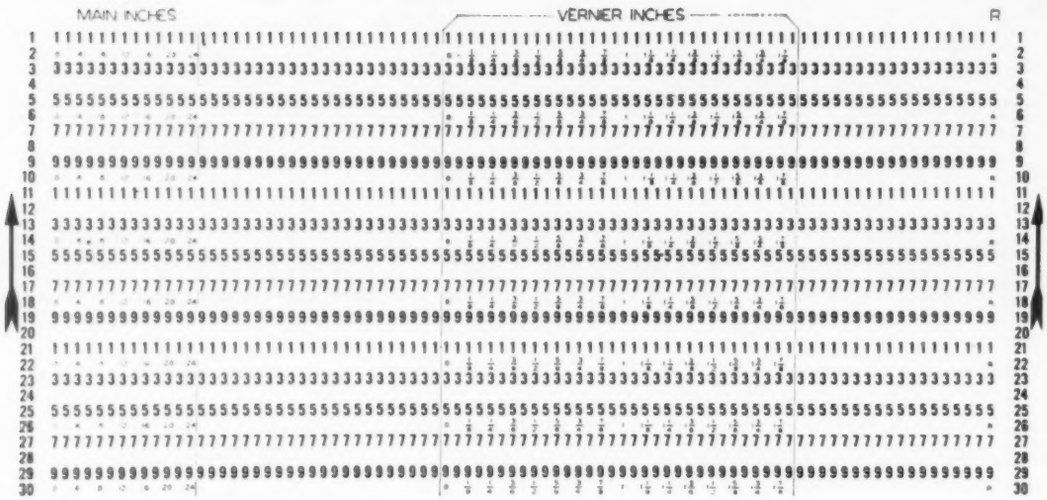
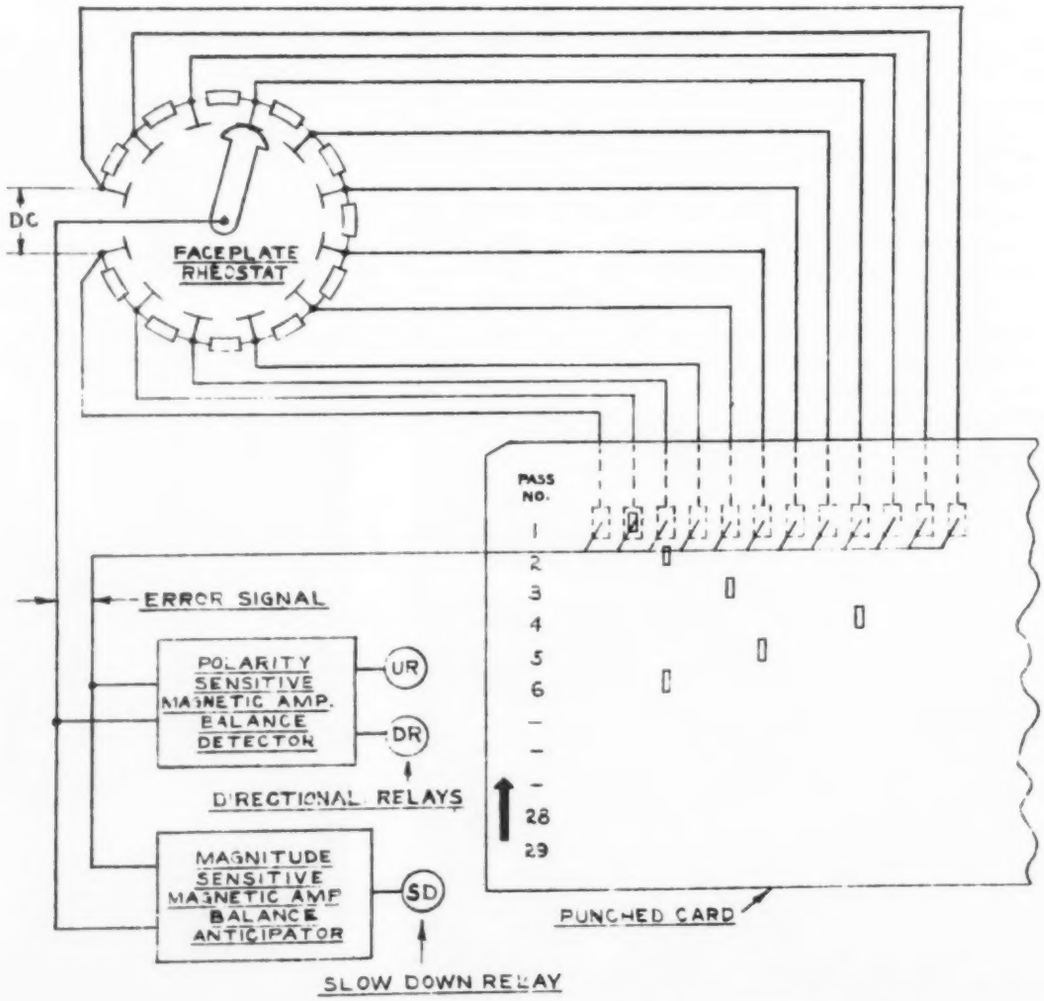


Figure 4 — The plastic card is divided into three sections.

plifiers, four on the main and three on the vernier. Each magnetic amplifier consists of two load windings and three control windings, two single phase half wave rectifiers and a resistor. These components are connected in a self-saturated magnetic amplifier circuit. The load winding operates the coil of the appropriate relay, connected in series with a resistor. Four full wave bridge rectifiers and four resistors make up control units, one unit for d-c to the bias windings of the four detector magnetic amplifiers, one unit for the bias windings of the three anticipator magnetic amplifiers, connected in series with resistors and slowdown selector switches which are calibrated in number of segments from balance that the slowdown will operate. The anticipators operate relays at the slowdown point to complete slowdown circuits to the driving motors. The two remaining units supply the control windings of the anticipator magnetic amplifiers, with rectified signal voltage so as to make their operation unidirectional, so that the anticipators will operate at the same

Figure 5 — Holes punched in the card permit contact to be made between movable brush type contacts and stationary contacts thus making an electrical circuit which sets up the screwdown sequence.



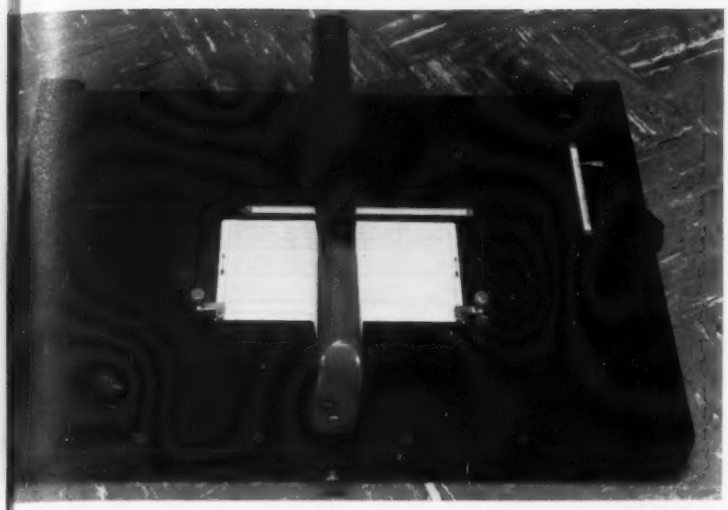


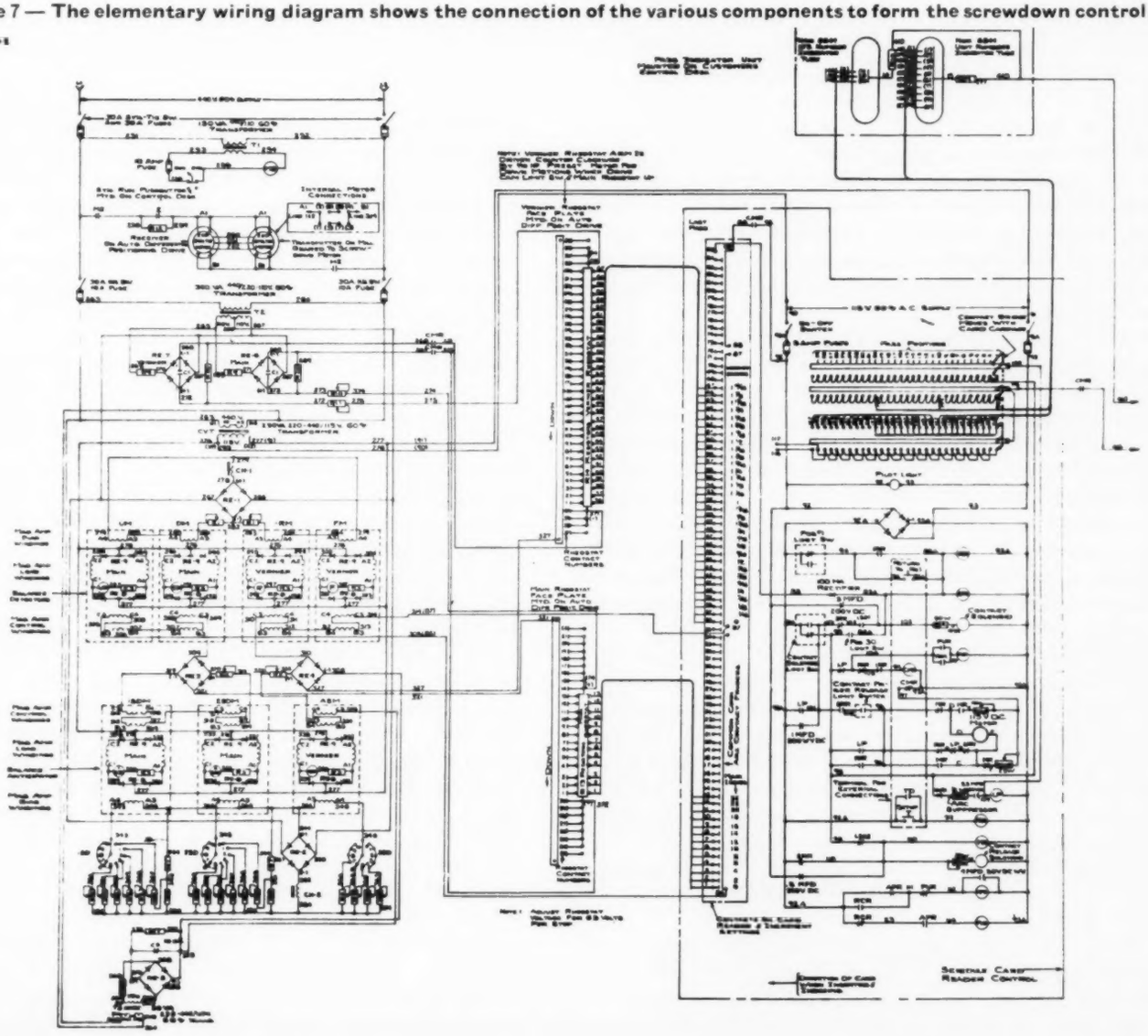
Figure 6 — Cards can be punched to permit use of a 30-pass layout which is more than ample for present needs.

selected distance from the balance point regardless of the direction the rheostat arm is approaching the balance point.

Voltage is supplied to the main and vernier rheostat circuits from a 220-volt transformer, rectified by separate full wave bridge rectifiers, and adjusted by resistors to give a 6.5 volt drop between segments on the rheostats. The main section on the card reader, the main rheostat, a full wave bridge rectifier, adjustable resistor and magnetic amplifier control windings make up components that are so connected as to complete a self-balancing bridge circuit. A second similar circuit is made up with the vernier rheostat and vernier section of the card reader. Due to the fact that more than 21 segments on the vernier rheostat are being used a current limit circuit is added to limit the maximum error signal current to protect the magnetic amplifier control windings. The d-c output voltage of a bridge rectifier supplies a bias voltage to the actual current limit circuit which is a resistor, capacitor and blocking rectifier, and is connected in series with the error signal current to the anticipator amplifier control winding.

Refer to Figure No. 7 an elementary diagram which gives a good picture of how the various component parts are connected to form a completely automatic screwdown control. To start the control on a complete cycle all that is necessary is to insert a card, punched for the desired schedule of roll openings, in the card entry slot of the card reader, and by moving card locking device, a small block mounted above the card entry

Figure 7 — The elementary wiring diagram shows the connection of the various components to form the screwdown control.



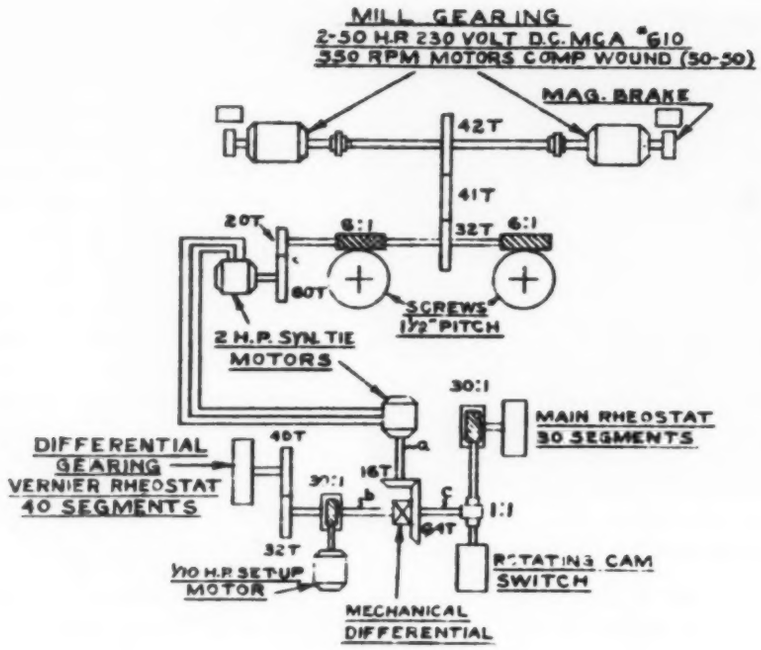


Figure 8 — The mechanical layout of the screwdown control and the connection of the synchronous tie motors are illustrated.

1 REV. OF SCREWDOWN MOTORS = 42/32 X 1/16 X 1½ = 21/64 ROLL TRAVEL
2" ROLL TRAVEL = 128/21 REV. OF MOTORS = 128/21 X 42/32 X 20/80 = 2 REV. OF SYN. TIE MOTORS
2 REV. OF SYN. TIE MOTORS = 2 X 16/64 X 2/1 (DIFF'L. FACTOR) = 1 REV. OF CUT-OUT = 2" ROLL TRAVEL

slot, to the right. The card locking device energizes the contact solenoid of the card reader which in turn raises the movable contact blocks to their operating position so that they will interpret line No. 1 as punched on the card. At this time, the preset motor will run to set the vernier rheostat arm at the segment corresponding to the information punched in the vernier section of the card.

With the main screwdown motors idle, the preset motor will turn both rheostats and the cam limit switch. Thus operation of the preset motor moves the main rheostat and cam limit switch backward or forward a fraction of a main increment. When the operator presses the push button marked "operate," the main screwdown motors will run to set the roll opening according to the information punched on the card. Any movement of the screwdown motors (see Figure 8), will cause a displacement of the contact arm of the main rheostat and the cam limit switch, but because of the locking action of the 30 to 1 worm gear reducer between the preset motor and the differential shaft, this prevents the vernier rheostat from being displaced. As soon as the main screwdown motors have stopped, the card carriage drive motor starts to run and advances the card carriage holding the card to line No. 2. The main screwdown motors will not start to run until the operate push button is pressed. The card reader carriage driver motor will continue to advance the card to the next line until the line on which "return to No. 1 position" is punched, at which time the movable contacts will release and the carriage will return the card to No. 1 position. During the rolling of one piece of metal, the pass indicator lights always indicate the next pass coming up, or that the control equipment is ready to setup the mill roll for that pass. As soon as the light comes on the operator may push the "operate" button. Whenever he so desires, the operator may take the operation away from the automatic control and use the manually operated master switch which operates the screwdown motors directly.

The functions of the various push buttons required to operate automatic control are as follows: "operate" button must be pressed momentarily each time that the operator desires to drive the roll to the next pass position. Under normal operating conditions this is the only button necessary to be used. "Return to No. 1" button is used to return the card reader to pass No. 1 position. This enables the operator to start over again on a schedule, or to change cards, etc. "Set-up" button is an emergency button provided to index the card reader one step at a time, each time the button is pressed. By using this button the operator may by-pass part of the schedule if desired. "Syn-run" button is provided to enable the operator to re-synchronize the automatic control with the mill, should the synchronous-tie motors get out of step for some reason, such as a power failure. The motors may get out of step due to difference in time of stopping. Upon return of power, to synchronize, the operator would bring the differential drive, card reader, and ratchet relay, to some known pass position, preferably a position near the middle of the roll movement, using the "set-up" push button. The "operate" push button should then be pressed, starting the screwdown motors and stopping them at this pass position. Assuming that the synchronous-tie motors have slipped, the roll will stop at some other position. Pressing the "syn" button disconnects the power to the synchronous-tie motors. Pressing the "man" button closes the under voltage relay. The roll is moved to the correct position, in syn-

chronism with the automatic control, by means of the manual master. Automatic operation may now be resumed, by closing the "run" and "auto" push buttons and pressing the "reset" button.

So far, the control has functioned satisfactorily. It operates the rolls at 15 fpm, which, if anything, is more speed than is really needed so far. Eventually the mill will be rolling bloom sizes starting at 7 x 7-in. up to size 12 x 24-in. reducing to billets ranging 4 x 4-in. to 8 x 8-in. and slabs 3 x 9-in. up to 4 x 30-in., the latter size obviously requiring a larger bloom.

This is the first application of this card reader to a reversing blooming mill. Others have since been installed, but this was the first one to be put into operation.

Discussion

PRESENTED BY

C. A. SCHURR, Supervisor, Control Systems Engineering, Electric Controller & Mfg. Div., Square D Co., Cleveland, Ohio

C. A. Schurr: The system which was recently installed on the 28-in. blooming mill at the Steelton plant has been described in some detail. It might be interesting to know some of the considerations which go into the design of controls such as these.

This installation represents one of more than 50 such controls which have been installed over the last 20 years. In all cases an effort has been made to design controls which are in keeping with the requirements of the specific problem, avoiding as much as possible the use of complex or unproved circuits or components. At the same time, much thought has been given to the future uses of these controls in more elaborate systems.

In this particular installation, it was felt that the customers' requirements could be admirably met by using the time proved system which has been described. Here a high-accuracy analog type of control system was used where programming was accomplished by reusable plastic punched cards which are sensed in an industrial type of card reader. A rheostatic control system was used to control a pair of compound-wound motors.

With these arrangements, it was possible to directly program the control system from the punched cards without the complications of a decoding network. These considerations are directed towards keeping the system simple and straightforward which is desirable from the standpoint of reliability and ease of maintenance. At the same time, consideration was given to the possibility of tying these same controls into a more automated system at a future date should this ever be desired. For example, automatic mill reversal and side guard control can be added as supplementary control equipment. These can be added in steps as desired without significant modification of the existing control equipment.

In other installations, modifications of this system or other basic types of control systems are more suitable. For example, in circumstances where the product is not changed frequently and where it is desirable for the operator to make occasional minor changes to the rolling pattern, a slider type of programming system best meets the requirements.

Should later circumstances indicate the desirability of a punched card type of programming, this can be readily added. It is even possible to keep the slider system along with the card reader.

In other situations, it might be desirable to program the system with instructions from an accounting system or some other such nerve center. In such cases, a card reader which can accommodate a standard business machine card is used.

There are instances where the system requirements may indicate an extremely high accuracy system. Here digital techniques may be applied which take advantage of some of the more sophisticated computer techniques and some of the more recent control engineers' tools such as the semi-conductors.

In such a system, position signals are converted to very precise digital equivalents—or numerical equivalents—and these numbers are compared to programmed numbers on punched cards in high speed static subtractors. The high accuracy output of the subtractor can be converted back to equivalent electrical signals which can be used to control large motors. Such systems are admittedly more complex but are not necessarily less reliable.

The systems can become even much more sophisticated. They can in effect be given minds of their own where decisions as to how the processing should be carried out can be made in computers built in to the controllers.

The important consideration is then to build control equipment which is designed for the specific problem taking into consideration all factors concerned with satisfactory installation, service, and maintenance. ▲

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Construction and Design Problems Involved in a

by ROLLIN A. SLATER
Manager of Plant Sales
Dwight-Lloyd Div.,
McDowell Co. Inc.,
Cleveland, Ohio

. . . . while the basic design of the machine has remained the same through the years, many refinements have been added to improve operational efficiency . . . .

ENGINEERS find it significant to note that the basic design of the original sintering machine has stood the test of time. Only refinements have been made. The scope of sintering, however, has recently taken larger strides. For example, the United States steel machine at the Ohio Works (Figure 1) is 54 times the size of the original machine. Sintering has become one of the prominent processes in recent steelmaking improvements. The word sintering, in its recent eminence, connotes varied thoughts to different people.

To blast furnace operators, it has become a means by which they approach production rates of four tons per sq ft of hearth area.

The connected load in this plant is 8568 hp. Two 10,000-kva transformers were installed in the area to replace the two 5000-kva that were in operation. This was done with no area outage. The two 5000-kva units were relocated and placed into service permitting the disposal of three 2000-kva units.

The 10,000-kva units were so large that house movers were employed for their transport.

At Ohio Works, there were many interesting decisions to be made. In order to clear the land for this plant, it was necessary for the owner to remove one-half million tons of flue dust from the north end of the yard which became the sinter plant site. Then for a foundation, 94,000 cu yd of fill were furnished by him and installed to support the plant and equipment already mentioned. To accommodate the foundations, 19,500 cu yd of slag were excavated for placement of 6500 cu yd of re-enforced concrete.

Some of the problems of plant location were intriguing: first, the actual site for the plant. It was ultimately decided to be the north end of the ore yard beyond the bridges. This necessitated a plan to revise the ore yard programming; also, it introduced a new concept of materials flow.

The source of incoming raw material was now more than 3000 ft away from the sinter plant site. It was decided that an economical approach would be to retain basic features of the ore yard operation; namely, that the bridges would handle material received along the east wall and service the furnaces along the west wall. The existing facilities included an old high-lift cardumper with winch haul arrangement which was designed to handle 15 cars per hr. It was decided to replace this facility with a new high speed rotary cardumper and winch installation with a cycle of 48 cars per hr. This installation was unique in that it used constant potential electrical control system rather than the customary variable voltage control.

In order to accommodate receipt of materials at a new high tonnage rate, it was decided to install a conveyor along the length of the ore storage yard connecting the cardumper and the new sintering plant screening station. The conveyor had to be capable not only of delivering ore to the screening station, but to distribute incoming materials to the existing ore yard. This required utilization of the space occupied by the existing transfer cars.

Removal of the transfer car system and its replacement with a new conveyor, No. 4, required extensive advance planning and its execution required close cooperation with the plant operation. Ohio Works scheduled its program in such a way as to first fill and then abandon successive sections of the storage yard from north to south. As each section was abandoned, the transfer car tracks were removed and the conveyor

New Sintering Plant

system installed in their place. This work was complicated by addition of a 15-in. cantilevered overhang section along the entire wall to provide room for the new equipment. Concrete was broken out and new steel embedded to accommodate this structure.

This schedule was so tight that when the last section of track was removed and conveyor installed, only several days of checkout were available before the entire system had to operate and replenish the then depleted ore reserves. This scheduling influenced such far away places as the ore loading docks in Mesabi regions. Fortunately, all went well.

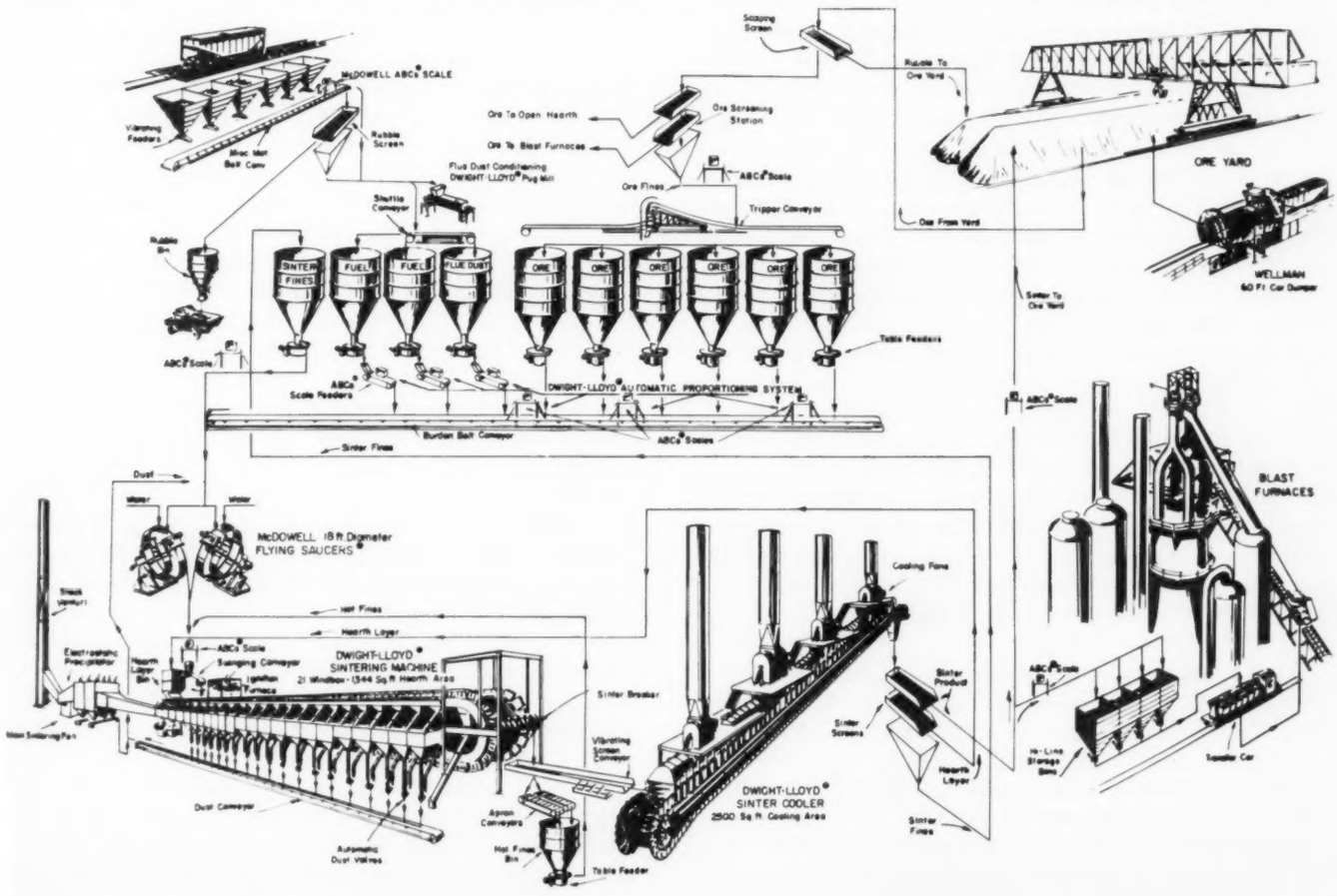
To perform the required functions, conveyor No. 4 was provided with two traveling trippers and two traveling hopper cars for service along its entire length. The trippers are each capable of discharging material either directly to the ore yard, or, by means of a rotating chute, straight ahead to the belt for delivery of material to the screening station. The hopper cars provide the function of enabling either of two bridges to remove material from the storage yard and load it onto the conveyor for delivery to the screening station. Thus, it is also possible to restock material from any southern portion of the yard to another location, by using a bridge, hopper car and tripper. It is also possible to place material into the yard while simultaneously loading material from another section of yard into the system for screening. Further, it is also possible to rough blend materials by using a combination of all facilities. Flexibility is very great.

In order to accommodate the expanding Ohio Works metal-making capacity, this entire system was designed to operate at a rate of 3000 tons per hr.

As indicated on the flow sheet, material being transported on conveyor No. 4, destined for the screening station, is first delivered to a 6 ft wide by 16 ft long scalping screen which removes the plus eight-in. lump material. The oversize lump material is returned to a pile in the north end of the ore yard by hinged boom conveyor. Material passing through the screen is then conveyed to surge bins which are required for this high capacity operation. At this location, six 150-ton bins are required.

Screening at a design rate of 1000 tons per hr, the

Figure 1—Simplified flow diagram of the sinter plant shows the movement of the material from ore yard to blast furnace.



surge bins nominally provide 20-min holding capacity for the incoming system. In the very limited area available, this is the maximum holding time that can be achieved.

The screening station and storage bin building is equipped with four 6-ft wide by 12-ft long double deck screens. At this station three sizes of ore are provided. The top deck of each screen is equipped with openings to segregate the plus 2-in. open hearth material, which can be directed to the open hearth loading-out station located along the eastern perimeter railroad tracks. The bottom deck of each screen is designed to screen at $\frac{3}{8}$ in., the oversize of which is separated as direct blast furnace feed. By means of manual flop gates, it is possible to combine the open hearth and blast furnace sizes to a common blast furnace feed product. The blast furnace ore is conveyed to bins located below the screen level for later dispersement. The material through the $\frac{3}{8}$ in. screen, the sinter plant feed material, are also directed to storage surge bins in this station for further routing. Note that storage bins are also located here for temporary storage of sinter products.

From these bins, it is possible to convey any of the materials back to the storage yard. It is also possible to direct the ore fines either to the yard or to the sinter plant by means of a reversible conveyor.

Material destined for the storage yard is transported along conveyor No. 5, which is located parallel to the yard and adjacent to the conveyor No. 4. Conveyor No. 5 is provided with a self-propelled tripper complete with a transverse boom conveyor that cantilevers over conveyor No. 4, and clears beneath the bridge structures. This conveyor services the northern half of the ore yard and is approximately 1500 ft long.

Feed for conveyor No. 5, originates at the screening station storage bins and is metered into the system by appropriate feeders. The sinter is regulated by vibrating feeders, and the ore by belt feeders.

In order to accommodate delivery of ore fines to the sinter plant storage bins, the collecting conveyor beneath the ore fines bins operates in a northern direction, with a system of belt conveyors that distributes the ore into the proper bins by traveling tripper.

The miscellaneous materials system is equipped for receipt of material either by trucks or by railroad cars. This system consists of a station provided with six trackhoppers which is equipped with a car puller and a car shake out. The rated design capacity is 300 tons per hr of flue dust or 98 tons per hr of coke breeze. A rubble screen is installed in this system to remove the plus $\frac{3}{4}$-in. material into a bin for truck removal. Also, a pugmill is provided atop the flue dust bin for the purpose of conditioning hot dust as it may arrive from the blast furnace dust catchers. The succession of bins containing miscellaneous materials is serviced by a shuttle conveyor.

The general layout of all the facilities was complicated by lack of available space and by the fact that the layout includes provision for future installation of flue dust thickeners and coke preparation unit, in which oversized coke would be stored and ground prior to delivery to the sinter plant.

This unique plant location, constructed in a bowl, also presented interesting problems of proper drainage and area access. To assure that the various problems were properly understood and to facilitate engineering studies, two scale models of the plant were made prior to approval of the design drawings. These models also served to instruct operators during the latter stages of construction.

Raw material storage in the main building is provided by ten circular bins, each 45 ft high, located in 24-ft bays. Each bin is equipped with a table feeder for regulated withdrawal of material. A complex proportioning system is required to accurately control the constituents of this mix. The functions of this system are: (1) to sample the rate of material being delivered, (2) to regulate the rate of material based on intelligence from the sampling device and (3) to maintain a constant predetermined ratio of one material to another. This mixing plan, based on Ohio Works' raw materials, is essential for its high capacity production of good sinter.

Fundamentals of the system include six ore bins, one miscellaneous bin, two fuel bins, one cold returns bin, one hot returns bin, the belt scales and the bin level probes and the saucer. It is a constant weight, gravimetric-type system.

Flow of ore to the system is controlled by means of variable speed table feeders which are regulated in groups of two, each group controlled by scale. The first two scales sense rate and transmit intelligence to a third scale which is an adjusting or trimming scale that makes final correction of ore tonnage to a desired level. Simultaneously it feeds back correction data to the preliminary scales, which then correct any preceding error.

The addition of miscellaneous materials is accomplished by scale feeders which are integral self-contained units. Each of these is interposed between the table feeder which it services and the collecting belt. Individual units are used here in the interest of ultimate accuracy. Units are designed to weigh and regulate, within one per cent, a portion of the material that is often less than ten per cent of the total on the belt at that point. A system of differential readings between two scales on the same belt would lead to cumulative inaccuracies. Thus, it is essential to use individual units to maintain maximum accuracy by operations within the design range of commercial units.

There is an interesting interlock between the function of the final ore scale and the fuel bin feeders. The rate of fuel addition is a percentage of the total ore as regulated by the final ore scale. A system of "feed-back" control is used here to accomplish this purpose with maximum accuracy.

There is also an interesting control which is employed to regulate addition of sinter returns. The requirement of this system is that the sum of the hot and cold returns shall be a constant. A complication results because hot returns are carried upon steel apron conveyors and conventional belt scales cannot be used for weight. Thus, they are weighed by differential scales on the final mix belt, immediately prior to charge of the sinter machine. This remote addition required the use of time delay systems.

Since it is desirable to consume hot returns as they are made, the hot returns bin is equipped with a system of bin level probes which indicate high level, operating level, and low level. A system of automatic table

feeder speed and adjustments is incorporated which retards withdrawal of hot returns when low level is reached, and advances withdrawal on high level. Speed changes that occur in the hot returns system are matched by an inverse speed change from the cold returns table feeder. Thus, the total of the fines in the system is maintained at a constant preset level by volumetric means. The belt scales provide gravimetric information which is used to calibrate the table feeder gate settings.

Further, the system is sensitive to changes in total weight being delivered to the machine. This is controlled by a reference line voltage which uses as the base factor the amount of ore in this mix. It is the operator's option to change the total feed of the whole system by the manipulation of a single rheostatic control which changes the voltage on the reference line.

Preparation of the sinter mix is accomplished in two 18 ft diameter mixers. To avoid segregation which could result in separating the feed to these units, a swing spout chute is installed at the junction where the split to each mixer is made. In the mixer water is added. This also is done gravimetrically, as the conveyor feeding each unit is provided with a belt scale which controls a motor operated water valve. Thus, all additions to the mix are under the supervision of electronic equipment.

The prepared material is then delivered to the feed well of the sintering machine. Height of the material in this well is regulated by level probes which supervise the speed of the sintering machine. It is important to avoid either starvation of feed, which would result in blow holes, or compaction of the bed, which would result in erratic air distribution.

The sintering machine is a big, modern machine equipped with forced lubrication, a natural gas ignition furnace, and a revolving sinter breaker. It is a rugged machine weighing 2,000,000 lb. To avoid excessive maintenance of some free fall discharge machines, an electro-dynamic retarder sprocket assembly is located near the drive end of the machine on the return strand. This keeps the pallets in contact around the discharge end.

Sinter passing through the breaker and grizzly is discharged onto a vibrating hot screen which removes the $^3/_{16}$-in. particles as hot returns. This machine is the new cold frame design constructed of special alloy tubular sections and provided with water cooling.

Sinter from the hot screen is delivered to the in-line sinter cooler which has an effective hearth area of 2358 sq ft. This cooler is equipped with four induced draft fans which handle a total volume of 760,000 cfm of air through the sinter cooler bed.

The use of the inclined straight line cooler provided relief to the limited area of the site by elevating the material for the return to the sinter screening station located atop the main plant.

Cooled sinter is conveyed to two 6 x 12 ft double screens, each of which is mounted on a carriage to facilitate maintenance. These screens are equipped with a $^3/_4$-in. opening top deck and a $^3/_8$-in. opening bottom deck. At this point sinter returns and hearth layer are separated from the product. Returns are chuted directly to a storage bin located below. The hearth layer fraction is conveyed by system of belts to its metering bin located at the feed end of the sintering machine. This hearth layer bin is equipped with level probes which, upon sensing high level, shut down this conveyor system. In case of such condition, the hearth layer fraction will overflow the feed chute into the sinter product system.

TABLE I
Operational Requirements

Material	Tons Per Day
Iron ore (Mesabi and Venezuelan)	5810 (minus $^3/_8$ in.)
Fuel (anthracite fines or coke breeze)	345 (minus $^1/_8$ in.)
Cold sinter returns	1285 (minus $^3/_8$ in.)
Hot sinter returns and dust	610 (minus $^1/_8$ in.)
Hearth layer	780 maximum $1^1/_2$ in. bed of sized sinter, plus $^3/_8$ in. minus $^3/_4$ in.
Flue dust (optional—not included in total)	30 (minus 20 mesh)
Total feed to machine	8830

Sinter product is delivered to either of two stations. One station is located on the blast furnace high-line and is equipped for loading of transfer cars. The alternate station is the holding bins at the ore screening station, previously described, from which product is returned to the storage yard by conveyor No. 5.

As a service to the public and in keeping with modern trends, this plant is equipped with considerable dust collection. Separate dry type units of 70,000 cfm and 15,000 cfm minimize air pollution. Also, individual units are provided for the electrical control centers and 20 tons of filtered air is made available at the operations control center for operator comfort.

Air for the sinter process, 14,500 tons per day, is induced through the system by a double width, double inlet fan, which provides 35-in. suction and is driven by a 3000-hp synchronous motor.

Speed control essential for flexible operation is provided by a dynamic coupling which gives full speed range selection up to 850 rpm. Process air is carried through the main plenum which was designed for a constant velocity of 4500 rpm maximum, and is then passed through an electrostatic precipitator.

This precipitator is a divided unit, provided with cutoff gates and equipped with 72 inlet lanes and 64 outlet lanes: and is rated in excess of 97 per cent efficiency.

Air is exhausted to atmosphere through a 10-ft mean diameter 120-ft high stack. In keeping with the total plant instrumentation scheme, this stack is provided with a self-calibrating full flow venturi section which records flow at the main instrument panel.

The following statistics are listed to conclude the Ohio Works plant analysis:

The plant is designed for an operational rate of 5000 tons of plus $^3/_8$-in. product per day, but has the equipment to produce 6000 tons per day. Provision has been included to deliver 14,000 tons of burden feed per day if desired. The above production would require the use of 40,000 tons per day of process air.

Operation of the plant has indicated that the amounts of materials given in Table I would be utilized during an average operational day, during which 5000 tons of product were produced. ▲

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, January 30, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Application of Natural Gas to Blast Furnaces and Cupolas," by F. F. Argust, Superintendent, Industrial Engineering, Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

Redmont Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, January 10, 1961—Dinner 6:30 P.M., Meeting 8:00 P.M.

"Operator's Role in Stream Pollution Control," by J. Kinney, Consultant, Ann Arbor, Mich.

Sheraton Hotel, 715 Delaware Avenue, Buffalo, N. Y.

CANTON SECTION

Monday, January 16, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Factors Involved in the Selection of Electrical Drive Ratings for Metal Rolling Mills," by A. F. Kenyon, Advisory Engineer, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

Mergus Restaurant, Canton, Ohio

CHICAGO SECTION

Tuesday, January 3, 1961—Dinner 6:15 P.M., Meeting 7:45 P.M.

"Symposium of New Mechanical Developments for Steel Mills"

"Hydraulic Bar Loopers," by David Lyle, Vice President, Engineering & Sales, Foundry and Mill Machinery Div., Blaw-Knox Co., Pittsburgh, Pa.

"Mash Welders for Light Gage Strip," and **"160-210 In. Plate Mill,"** by W. L. Stover, Assistant Chief Engineer, Mesta Machine Co., Pittsburgh, Pa.

"Convertible Horizontal to Vertical Bar Mill Stands," by G. L. Sanders, Product Manager, Industrial Equipment Div., Baldwin-Lima-Hamilton Corp., Philadelphia, Pa.

Phil Smidt's Restaurant, 1205 North Calumet Avenue, Hammond, Ind.

CLEVELAND SECTION

Tuesday, January 24, 1961—Social Hour 6:00 P.M., Dinner 6:30 P.M., Meeting 8:00 P.M.

"The Future of Steel," by Dr. H. P. Munger, Head, Metallurgical Div., Research Center, Republic Steel Corp., Cleveland, Ohio.

Cleveland Engineering and Scientific Center, 3100 Chester Avenue, Cleveland, Ohio

COLORADO SECTION

Tuesday, January 17, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Mine Roof Bolts," by Ralph B. Moore, President, Ralph B. Moore, Inc., Denver, Colo.

Minnequa University Club, Pueblo, Colo.

DETROIT SECTION

Tuesday, January 10, 1961—Dinner 6:30 P.M., Meeting 8:00 P.M.

Ford Steel Division Night

"The New Humboldt Pelletizing Operation," by N. E. Rothenthaler, Operations Manager, Blast Furnaces and Coke Ovens, Steel Div., Rouge Plant, Ford Motor Co., Dearborn, Mich., with W. A. Shockley, Manager, Minerals Processing Machinery, Processing Machinery Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.; Alan English, Staff Engineer, Arthur G. McKee & Co., Cleveland, Ohio; Kenneth C. Ofsen, Superintendent, Humboldt Mines, Cleveland Cliffs Co., Cleveland, Ohio; and Norman Eyler, General Foreman, Sinter Plant, Steel Div., Rouge Plant, Ford Motor Co., Dearborn, Mich.

Dinner, Cafeteria; Meeting, Auditorium, Central Office Building, Ford Motor Co., Dearborn, Mich.

LOS ANGELES SECTION

Monday, January 9, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Maintenance Symposium," Chairman, Verl R. Smith, Chief Draftsman, Plant Engineering Dept., Bethlehem Steel Co., Pacific Coast Div., Los Angeles, Calif.

Holiday Inn, Chino, Calif.

PHILADELPHIA SECTION

Saturday, January 7, 1961—Dinner 6:00 P.M., Meeting 7:00 P.M.

"Redesigning for Product Improvement and Cost Reduction," by W. T. Geiger, Superintendent, Hot Strip Mill Finishing and Cold Strip Mill, Alan Wood Steel Co., Conshohocken, Pa.

"Air Pollution and Its Control in the Steel Industry," by Victor H. Sussman, Chief, Air Pollution Control Section, Department of Health, Commonwealth of Pennsylvania, Harrisburg, Pa.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

PITTSBURGH SECTION

Monday, January 9, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Steel Plant Maintenance Problems and Some Solutions,"

"Epoxy Resins Aid Steel Plant Maintenance Men," by Elmer Barthel, Assistant Superintendent-Maintenance, Pittsburgh Steel Co., Monessen, Pa.

"What Maintenance Does The Sinter Plant Designer Expect?" by J. H. Porteus, Chief Development Engineer, Engineering and Construction Dept., Dravo Corp., Pittsburgh, Pa.

"Refractory Maintenance in Basic Oxygen Steelmaking Process," by Carl Willenbrock, Refractory Engineer, Harbison-Walker Refractories Co., Pittsburgh, Pa.

"Maintenance of Electronic Equipment," by Arnold G. Shumaker, Assistant General Foreman, Maintenance, Tinplate Div., Jones & Laughlin Corp., Aliquippa, Pa.

"Thoughts on Record Keeping As An Aid to Maintenance," by Harold R. Miller, Superintendent of Maintenance, Armco Steel Corp., Butler, Pa.

University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

Wednesday, January 25, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Future Sources of Energy," by J. J. W. "Bill" Brown, Manager—Direct Conversion Projects Operation, General Electric Co., Schenectady, N. Y.

Elks Club, Granite City, Ill.

SAN FRANCISCO SECTION

Tuesday, January 17, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Pacific States Steel Night

"Modern Concepts for Steel Mill Conveyor Drives," by Robert C. Bush, Application Engineer, Industrial Div., Central Marketing Group, Western Gear Corp., Belmont, Calif.

Spenger's Fish Grotto, 1919 Fourth St. (near University Avenue), Berkeley, Calif.

UTAH SECTION

Monday, January 9, 1961—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

"USS Atlantic City Project," by S. H. Cohlmeyer, Project Manager, Atlantic City Ore Mine, Fremont County, Wyo.

Grandview Cafe, Provo, Utah

YOUNGSTOWN SECTION

Monday, January 23, 1961—Social Hour 6:30 P.M., Dinner, 7:00 P.M., Meeting 8:00 P.M.

"Analysis of Today's Tube Welding Processes," by Norbert C. Rubin, Vice President, The Yoder Co., Cleveland, Ohio

Mahoning Country Club, Girard, Ohio

DEPENDABLE OXYGEN SUPPLIES

by T. A. DONEGAN
Southern Regional Engineer
Linde Co.,
Div. of Union Carbide Corp.,
Birmingham, Ala.

. . . . on-site gaseous oxygen plants are becoming the chief source of supply for much of the oxygen required by the steel industry . . . .

NO account of the American steel industry's rapid progress in recent years would be complete without a report on oxygen and its growing role in modern steelmaking processes. Steel mills throughout the U. S. are seeking new ways to boost capacities of existing equipment, to increase operating efficiencies, and to improve the quality of their products. Many have found solutions to these problems through increased use of oxygen.

For a better understanding of the potential opportunities that lie ahead, it is appropriate to review how the growth of air-separation technology has paced the steel industry's use of oxygen. Today on-site oxygen plants, Figure 1, are supplying steadily increasing volumes of oxygen for established uses such as cutting, lancing, hand scarfing and machine conditioning, plus a truly remarkable surge in the use of oxygen in open hearth and electric furnaces.

A statistical yardstick of the soaring demand for oxygen is the oxygen per ingot ratio—the number of cu ft of oxygen used over-all in the production of a ton of steel ingot up to the time it leaves the mill. Oxygen per ingot ratios have increased steadily over the years, going from 60 in 1946 to 100 in 1949, to 150 in 1953, to 200 at the end of 1957. Throughout 1958, ingot ratios continued to increase from about 240 cu ft per ton to over 300 cu ft per ton. Furthermore, it is significant to note that the oxygen per ingot ratio increased throughout the recession period when cutbacks and economy measures were the order of the day.

This is quite an impressive record when one considers that oxygen processing had its start in steelmaking only two decades ago. And it is a record that would not have been possible without the rapid technological progress in cryogenics that has made oxygen available in larger quantities, at lower costs, from highly reliable production facilities.

The latent opportunities for oxygen in steelmaking were foreseen during the early 1940's. Soon after the first experiments indicated the potential economic benefits of oxygen additions to the combustion zone of open hearth furnaces and to the baths of open hearth and electric furnaces, we set out to develop a whole new family of air-separation plants engineered to produce tonnage quantities of gaseous oxygen economically and dependably.

Our first commercial on-site gaseous oxygen plant, a 150-ton per day plant built in 1948, started up without any serious difficulty and has remained in operation for better than 98 per cent of the time since going on stream. Designs for plants of both smaller and larger capacities followed, and today we have in operation or under construction more than 40 on-site air separation plants ranging from 10 to 1000 tons per day.

The ability today to obtain 100, 500 or even 1000 tons of oxygen a day merely by opening valves is in startling contrast to oxygen production methods of twenty years ago. Today, on-stream availability factors closely approach 100 per cent and most outages which do occur are for thaw-outs and preventive maintenance, and are scheduled in advance to coincide with periods of least demand. Even during outages, oxygen for processes which must go on can be provided from regular liquid production and distribution systems.

Figure 1 — On-site plants are supplying much of the oxygen for many steel mill uses, uses which multiply with the technological progress of the industry itself.

In the early days of the oxygen business, however, much less was known about the mechanics of air separation, and the available machinery was often costly, inefficient, and expensive to maintain. Many of today's automatic controls were unavailable, and therefore constant supervision and a considerable number of operating personnel were required. Also, facilities for maintenance and repair occupied a generous share of the plant building. Operators had to be continually alert to compensate for upsets and unbalances occurring in the columns and heat exchangers which would cause fluctuations in product purity, for freeze-ups from accumulated ice and solid CO_2, for dangerous concentrations of hydrocarbons in the system, as well as breakdowns in a considerable number of reciprocating engines, pumps, compressors and other motive equipment.

Supplying the large volumes of oxygen demanded by the new metallurgical processes one could then see developing, without interruption and at prices that could justify the use of oxygen for its fuel savings alone, demanded new concepts in the sale of oxygen, and new plant designs to produce oxygen. Ideally, such a new plant should be able to operate automatically, without attendant labor or supervision; to follow the peaks and valleys of mill oxygen demands on an hourly, daily and monthly basis; to monitor the purity of the product it was making; to keep tabs on its own operation, and shut itself down and call for help if any unsafe condition began to develop but to continue to supply oxygen continuously and without interruption during the interval required to repair the malfunction. One may say that such an ideal is fine in concept, but hardly possible of attainment in practice. Actually, there are seventeen such plants in operation in the U. S. There are considerably more than twice that number of our on-site plants in operation, but not all of them do all of the things I mentioned.

Next, consider briefly, the supply concept which would provide the greatest incentive to potential users of these large volumes of oxygen. It was reasoned that a steel producer would ideally want to buy oxygen at a price fixed, as nearly as possible, over a long term, say ten to fifteen years; he would still, however, like to be able to take advantage of any reductions in the cost of electric power needed to operate the plant which new technology might bring; furthermore, he would like to "share the risk" so that he would pay fewer dollars when he used less oxygen, and more dollars when he used more, on the theory that when he used more, he was making more steel and had more dollars coming in; also, when he was shut down by strikes or disasters, he would like to pay only the very minimum fixed capital charges. Most important, the steel producer would like to do all this without having to invest any money of his own in oxygen plants, as he had plenty of use for his capital in his own mill. We believed this was the business basis on which steel makers would ideally want to obtain their oxygen requirements. These policies were reviewed in detail with our steel customers, and were then adopted.

Having described an "ideal" oxygen supply system, and an "ideal" business concept under which to operate it, what were some of the engineering problems which had to be solved before this ideal oxygen plant could become a reality?

The engineering problems encountered in the design of air-separation processes can be grouped into three main categories. First in the sequence of operation is the removal of moisture and CO_2 from the incoming air which would otherwise freeze out and plug up the equipment. Next come the complex problems of heat transfer, and this is a very important factor since it determines overall operating efficiency and economy. To minimize losses in the air-separation system, it is essential that the heat content of the warm air entering on one side of the heat exchanger be transferred as efficiently as possible to the cold products passing out through the other side. The third major design category takes in all of the system components involved in the actual separation of oxygen from the other gases of the air.

To come up with the improvements and innovations that are largely responsible for the success of today's large volume gaseous oxygen plants, we explored many new approaches to engineering and operating problems. The new designs required intensive investigation of new heat-exchange concepts at temperatures as low as minus 297 F, new types of automatic control devices, new methods of insulation, and considerable improvement in gas-phase oxygen compressors. The solution to this last problem proved to be one of the key factors in the over-all design of the new family of plants.

There has been available for almost 20 years high-pressure, liquid-phase oxygen compression systems with hundreds of such compressors in service. But to meet the requirements of a highly automated on-site oxygen plant, operating continuously and with the minimum of supervision and maintenance, gas-phase compressors promised the greatest savings in over-all terms of plant investment and power cost. Unfortunately, low-pressure gas-phase compressors then available were costly, hard to maintain, and poorly lubricated. In cooperation with leading compressor manufacturers, we undertook a development program that eventually led to improved packings and lubricants in place of the less satisfactory water lubrication and carbon ring packing that had long been the industry standard for gas-phase compression equipment.

When it came to revamping of condenser design, the engineers found there was still a lot to learn about heat exchange at cryogenic temperatures. The physical properties of gases under normal conditions were well known. But vital statistics on gas characteristics, such as heat content and entropy at liquid air temperatures were inadequate. To supply values needed for critical heat-balance and heat-flow calculations, new laboratory techniques were developed in order to measure and establish physical and thermodynamic properties and data in these supercold temperature areas.

One of the key processing units dependent on these data is the reversing heat exchanger. In this equipment, air entering through some passages is cooled by waste nitrogen exiting through others. As the air becomes colder, water vapor and carbon dioxide freeze out and are deposited on the walls of the tubes. The two gas streams are periodically switched so that the accumulated ice and frozen carbon dioxide deposited on the tube walls are flushed out of the system by the out-going waste products. During the course of a cycle, heat-exchange conditions vary as frozen impurities are gradually deposited in the air passages at one rate while they are being removed in the nitrogen stream at a different rate. The resultant changes in temperature levels and gas flow rates require careful mathematical study to assure the proper balance between air at 75 psi and nitrogen at essentially atmospheric pressure.

Here again, problems were encountered that required close cooperation with equipment manufacturers. In some cases, it was necessary to buy heat-exchange surfaces from the fabricators and then assemble them into equipment as needed for a given operation.

Throughout the development of on-site gaseous oxygen plants for the steel industry, commercial-scale testing of new designs was an essential part of the program. During this period, a pilot plant was constructed for the evaluation of new operating principles, while full-size components of column and tray sections, heat exchangers, compression systems, expansion turbines and control devices were performance-tested as auxiliary attachments to existing tonnage liquid oxygen plants in production at several sites.

Today, complicated and often interrelated operations involving hydraulics, fluid mechanics, mass and heat transfer, and strength of materials can be expressed mathematically for solution by new computer techniques. The computer has become a very important and useful engineering tool, since even the so-called "standard" plants may require as much as 30 per cent re-design to tailor them to the specific requirements of a new installation.

The instrumentation employed in these oxygen plants consists of conventional types of automatic controls. The engineers had to acquire special knowledge of control parameters of low-temperature systems to assure operating stability throughout. Methods for measurement and control of low temperature fluids had to be developed.

By virtue of these highly reliable controls, interconnected to obtain "fail-safe" operation, the accuracy of instrumentation is substituted for the human element in monitoring temperature levels, product purities, pressure, flows, etc., throughout the complex system, instantaneously making compensations and adjustments in controls for optimum performance. Furthermore, instruments and controls can be physically located at critical points inside the heat exchangers and the column structure, without provision for light and air, space to move about in, temperature levels, and other "working conditions." Properly engineered and instrumented, one of these plants can automatically increase or decrease its production rate in response to the demand for oxygen, can deliver oxygen from gas storage to handle momentary peak loads, and then refill the storage when demand falls off. If more oxygen is required than can be satisfied by production and accumulated gas in storage, the plant will automatically begin to vaporize liquid oxygen at the proper rate to make up the difference.

Selecting the proper size of oxygen plant for a particular installation is not a simple job, and the penalties for being wrong are both severe and lasting. For example, the cost of oxygen from an 80,000,000-cu ft per month plant will be almost half the cost of the same volume from four 20,000,000-cu ft plants. Therefore, if a mill's oxygen usage will reach 80,000,000

cu ft per month in three, four or even five years from today, it makes sense to put in the 80,000,000-cu ft plant at the outset.

"Capacity" is a measuring stick which cannot be applied to the plant alone. The oxygen supply system consists of the producing equipment, compression equipment, gas storage, liquid storage, and the production, transportation and distribution equipment for liquid oxygen. Having designed and sized the production equipment for most economical production, the base-load oxygen compressors must be adequate to deliver production into the line; the booster compressors must be able to refill gas storage receivers from excess production in the proper time, but without penalizing the economics by being too big and too costly. The volume of gas storage should ideally be such that the plant can run continuously at the most economical level, and all the peaks and valleys of demand be handled by putting oxygen into and out of the gas receivers. Obviously, a careful study of present and predicted future load patterns on an hourly basis is required to optimize gas storage receiver capacity for least over-all cost. Then how about liquid oxygen storage and vaporizing capacity? Since our on-site plants are tied into a liquid oxygen production and distribution system of virtually limitless capacity compared to an individual mill's requirements during an outage, it is not necessary to maintain a large liquid inventory on site and, in fact, excess investment in liquid oxygen storage capacity can impose real penalties on over-all economics. Proper sizing of liquid storage capacity is a function both of the time required to get supplemental liquid oxygen flowing from the regular liquid system and the amount which will be consumed during that interval.

In addition to the supply of "back-up" liquid oxygen during plant outages, there are infrequent "peak" demands beyond the combined capacity of the producing equipment and gas storage. These "peak" requirements may be for test programs such as oxygen enrichment of blast furnace air, oxygen-natural gas scrap melting burners for electric furnaces, etc. Likewise, the necessity for pushing the mill's steel production to meet the threat of an impending strike, or to be able to book a big order, may require oxygen volumes in excess of plant capacity which has been sized for best "normal" economics. Here again, the market value of the extra steel production might not be realized if the extra oxygen capacity permitted by supplemental liquid oxygen deliveries were not available. Just as in sizing blast furnace capacity, new rolling mill capacity, soaking pits, coke ovens, or any other component of an efficient integrated steel mill, the requirement is "enough, but not too much!" Enough capacity to satisfy normal requirements and allow freedom for growth, but not too much so that the charges for idle capacity price you out of today's market. Fortunately, there is a flywheel to smooth out fluctuations and some "extra capacity" which costs far less than an idle plant standing by. Liquid oxygen systems are today delivering hundreds of millions of cu ft of oxygen monthly to customers who require additional oxygen. Some mills at which we are building on-site facilities are enjoying the benefits of oxygen availability, even though the oxygen producing equipment is not scheduled for completion for some months ahead.

In addition to acting as a standby plant to supply peak and unexpected requirements, and supplying oxygen even when the plant is shut down for thaw-out or maintenance, the liquid system has other valuable uses. For example, one can get a plant back "on stream" after a normal shut-down for thawing much more quickly by dumping liquid into the column than by a routine startup from warm conditions. The difference between the flying start and the slow process of pulling yourself up by your own bootstraps may be as much as two or three days under some conditions. How much is two or three days of oxygen availability worth?

Last in this discussion, but certainly not least in importance, is the organization and the know-how standing behind the operation of this complex oxygen supply system. Maintenance and supervision of highly automated plants requires unusual skills and a thorough understanding of the function and operation of the many components. The plant superintendents assigned to these on-site plants have had advanced technical training, plus several years of on-the-job training in all phases of the production department, plus extensive training to become familiar with all phases of on-site plants. In our organizational structure, the engineering laboratory, which first designed the plant, regularly provides technical service to the production department, and conducts regularly scheduled training courses for production department personnel assigned to on-site plant operations. In emergencies, or when major maintenance is required, teams of qualified supervisory personnel are made available to complete the work and get the plant back on stream.

Because the supply concepts are as identical to the mill's interests as possible, the mill will automatically receive the benefits of many improvements, modernizations, etc., without any charge. For example, under our theory of supply of product, we make a return only when we are actually delivering product, and we therefore have the best kind of incentive to keep our plants on stream. Consequently, when the operating reports flowing back to the engineering laboratory indicate the need for better type of valving in some component, that improvement is made and incorporated in the plants. We do it because we want to keep operating, and mill management shares our interest in this objective.

To get where we are today has required considerable original work in such diverse technical fields as hydraulics and fluid mechanics, thermodynamics, materials investigation, piping design at extreme temperature conditions, instruments and controls and many others. We have also had to evolve a supply concept that gave the maximum community of interest between supplier and consumer. We think that the results have been good both for ourselves and for the steel industry. But the knowledge gained in this enterprise has served only to disclose how much more there is to learn. As a new frontier is opened up, it discloses new horizons. All of us have only begun to realize the benefits that oxygen and other products of air separation and cryogenic technology can bring to the steel industry and to the nation. ▲

by A. DUENNEWALD, Mannesmann Tube Co. Ltd., Sault Ste. Marie, Ontario, Canada

Operation of a Single Groove Plug Mill

Mannesmann's single groove plug mill—operating at speeds of up to 1500 fpm—produces seamless line pipe with closely controlled wall tolerances.

THE Mannesmann automatic seamless mill which covers a rolling program of 4½ to 10¾-in. casing, and 4 to 10-in. line pipe, has been described already in a paper published in February, 1959, in *Iron and Steel Engineer* entitled "Mannesmann's New Seamless Mill at Sault Ste. Marie," by Robert Hartenstein and Astor L. Thurman. When operators from other seamless mills come to Sault Ste. Marie to visit our plant, they usually ask: "What was the purpose of the complete redesign of the plug mill, and how does the single groove plug mill operate?"

The paper previously mentioned describes the new single groove plug mill very briefly, but we would like to give more detailed information of the operation and the thinking which lead to its design. The main consideration which was given to the design of each basic machine, was to maintain a high production level and fast mill changes to other pipe sizes. In practically all previously built seamless mills of this type, the plug mill has always been the bottleneck in the rate of production. Since the plug mill was the bottleneck, it was necessary to decrease the cycle time and at the same time the amount required for mill changes. Change-over time is even more important when it was considered that this mill should be flexible enough for size changes in a time period of less than two hours. The first point is the reduction of the plug mill cycle time itself.

Since the plug mill cycle is a combination of manual and mechanical effort and since we were designing a new mill we would have to use inexperienced labor, it remained to decrease the mechanical portion of the cycle time. Due to the fact that the development of all types of modern rolling mills centered around the increase of rolling speed, this seemed to be the logical solution. The most obvious answer would be to use faster drives, but a new problem arose when the friction requirements were considered: would there be sufficient friction at this high speed to grip the shells for proper entrance into the groove? This was made even more difficult because there was no past experience on similar mills from which one could draw a comparison. Up to the present time, plug mill speeds varied from 500 to 700 fpm. In order to make any significant decrease in the cycle, it was necessary to double these speeds.

It had been experimentally established that the friction factor, which is a function of temperature and speed, decreased rapidly with increasing speed and decreasing temperature. For example: using a cast iron roll, operating at a steel temperature of 1900 F, at a speed of 400 fpm, the friction factor has a value of 0.3. Doubling the speed to 800 fpm, at constant temperature, decreases the friction factor to 0.2; increasing the speed to 1100 fpm, decreases it to the low value of 0.1. Therefore, by almost trebling the speed, the friction factor was cut to one-third of its former value. This meant that it would be extremely difficult for the rolls to grip the shell at the desired high speeds.

Considering all these facts, the vice-president of operations, Dr. Rolf Bungeroth, attempted to solve the problem by having the shell enter the plug mill at low speeds and immediately accelerate to a higher speed. This now became a problem for the electrical engineers, and was effectively overcome.

The plug mill drives are an entirely new design. The practice was to use a single drive motor, and, through a gear unit, drive the top and bottom rolls. However, with this type of arrangement, it was proved that the load distribution on the rolls was not equal, although their speeds were the same. This caused inconsistent wall and whipping around of the shell back end while rolling. Therefore, it was decided to use individual direct drives. This allowed us to compensate roll speeds for unequal load distribution by changing the speed of an individual roll and to compensate for rolls which were not exactly the same outside diameter.

The acceleration itself takes place in the following manner: the plug mill operator can preset individually the low and high speed limits on his control desk. When the shell from piercer No. 2 is pushed towards the plug mill, an infrared detector is adjusted so that it picks up the signal when the shell is two ft from the rolls.

This signal begins the cycle, so that the rolls accelerate from the present slow entrance speed to the faster operating speed. The premature commencement of the acceleration is necessary because if it began with roll contact, the initial entrance load would drop the speed to even a lower value, meaning that acceleration would begin from a speed lower than the present value and would take longer to reach the operating higher speed. As an example: on a 4½-in. outside diameter pipe, the time required for accelerating from 660 to 1180 fpm, is 0.8 sec; on a 10¾-in. ouside diameter pipe, accelerating from 750 to 1500 fpm, requires 0.9 sec. It is obvious that this is an advantageous arrangement because it gives the rolling speed wanted and the entrance speed necessary to pick up the shell.

The electrical drives themselves are two 2000-hp d-c motors. They are capable of 260 per cent momentarily

overload frequently applied; 300 per cent occasionally applied; and 125 per cent continuously applied for two hrs. The speed range can be varied from 70 to 180 rpm, and acceleration ranges are from 70 to 120 rpm, and from 120 to 180 rpm. The power supply is a motor-generator set with variable voltage type of control. The motor is a 3000-hp a-c wound-rotor type, using a liquid rheostat for starting and dynamic breaking if required. It drives two 1750-kw generators and a fly-wheel of 1.56×10^6 lb-ft^2 inertia when rotating at 514 rpm. The fly-wheel provides stored energy for momentary peak loads. This additional bit of data concludes the discussion on the electrical setup.

Next consider mill changes on the plug mill. The mill is designed so that when a schedule change or roll change is required, the complete mill is removed and a previously prepared spare mill is installed. Time required in this mill change-over is cut down by its unique design. The two basic components, the main roll stand and the stripper roll stand, are separate units which are anchored by hydraulic wedge type locks to the same base plate. Also, the drive couplings can be disconnected from the roll shaft hydraulically. These improvements can be illustrated in the following manner: After the operating and maintenance crews have disconnected all water and grease lines, the 56-ton crane lowers into position a specially designed carriage with four-point suspension. At the same time, the hydraulic wedge-locks on the base plate are disengaged, and the couplings on the main drives are unlocked. All that remains is to lift the mill out of its foundation, transport it to a prepared maintenance area, and lower the spare mill into position. The stripper roll stand is changed in the same manner. When in place, the hydraulic wedges are locked and the couplings are reconnected. As soon as the grease and water connections are made, the mill is ready for operation.

Finally, the following is perhaps the most unique feature of the single groove roll.

Since the seamless industry was required to improve quality and especially wall tolerances, it was decided that the amount of play in the main rolls had to be reduced. This could be overcome by the use of heavy-duty anti-friction roller bearings. However, this in turn required a bearing face hardness on the shaft of at least 480 Brinell. Steel shafts were found more adaptable because:

1. The bearing faces were more easily flame hardened.
2. Due to the higher strength in steel, smaller shaft sizes could be used which require smaller and less expensive anti-friction roller bearing units.
3. Wabbler cracking would be eliminated due to the higher impact strength of steel.

In cooperation with the roll manufacturers, we were able to shrink-fit the roll bodies to the shaft, the roll being of the normal iron base type. Since larger multi-groove rolls would increase the difficulty of this operation because of the size of the main body, it was one of the reasons we decided to use a single groove. Further reasons would be the simplified design of the inlet trough and mandrel bar bed which could be permanently built on a solid foundation and result in a constant center-line for the mill. An interesting feature of the inlet trough are the shell indexing rolls. Instead of manually turning the shell 90 degrees between passes, this is done by separately driven raise-and-lower indexing rolls which are operated from the plug mill pulpit. This has proved safer and faster than manual operation and more worthwhile than previously anticipated.

In conclusion most of the efforts to increase the speed of the plug mill have been successful to the point that the bottleneck has been transferred to piercer No. 2, despite continuous rolling on 11-degree feed angle and a thrust block speed of 1000 fpm. Therefore, the success at the plug mill has initiated a problem at our piercing mill. ▲

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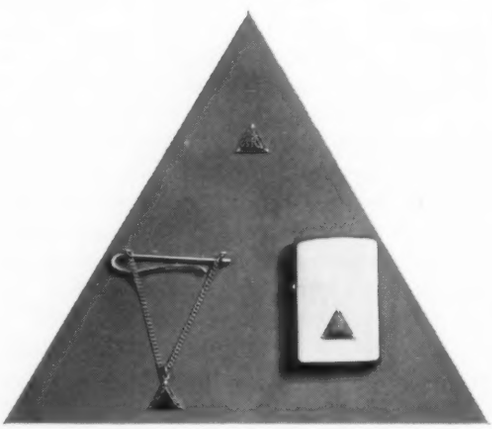

ASSOCIATION OF IRON AND STEEL ENGINEERS

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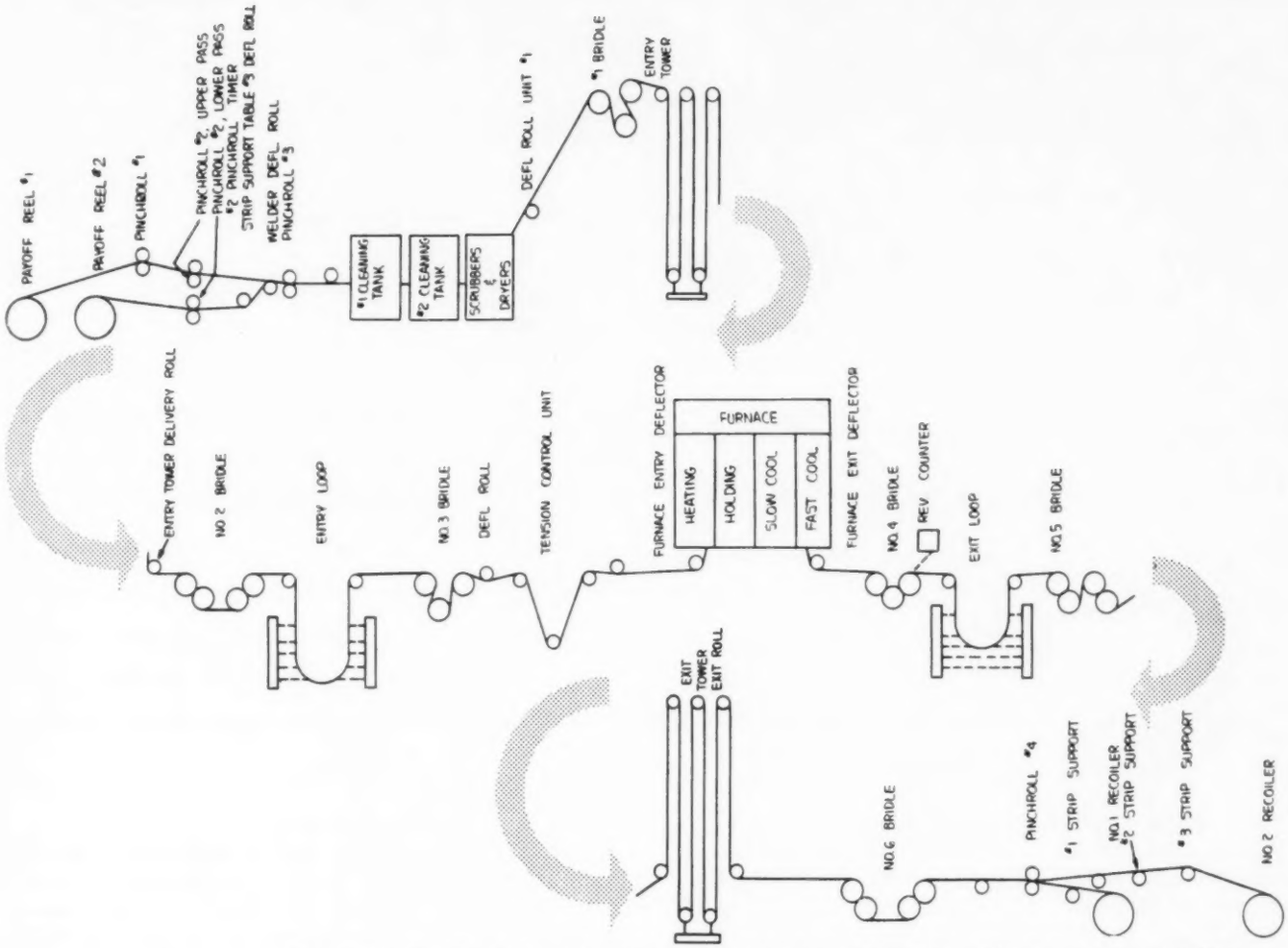


Figure 1 — The line is capable of annealing strip from 22 to 38 in. wide at speeds up to 1500 fpm.

Continuous Annealing Line DRIVE SYSTEMS

by R. M. BOSSHARDT, Application Engineer
Reliance Electric and Engineering Co., Cleveland, Ohio

. . . . higher production rates with better quality, together with automatic fault-finding devices, are the result of improved continuous annealing lines . . . .

PRESENT and projected plans for the installation of high-speed, continuous strip annealing lines are developing in an ever-increasing number, as the demand for quality product from such processing lines increases.

As the art of continuous annealing evolves, it is worthwhile to examine the most recent installations in order to learn about the technical advances and unique systems being used. Thus, assurance is gained that the next line will mark an advance in production tonnage with improved quality, operation and maintenance.

Important in any continuous processing line is the

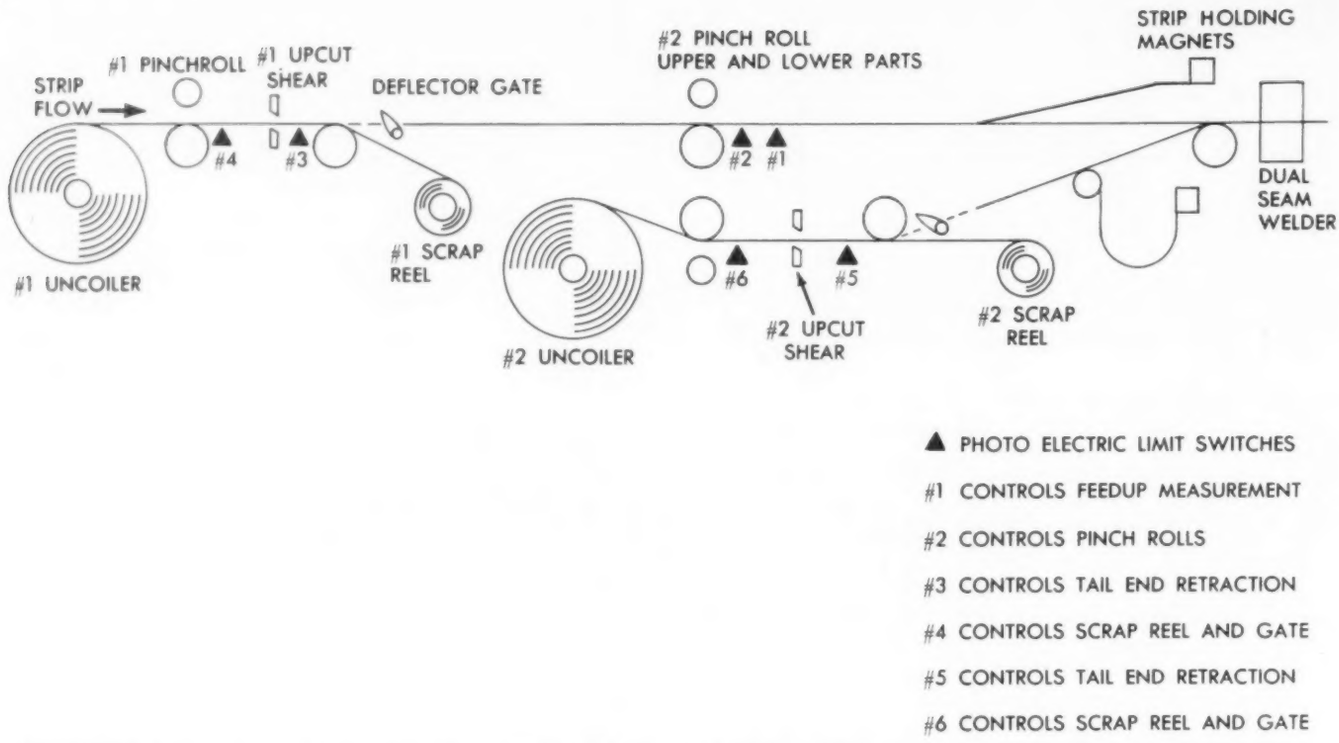


Figure 2 — Off gage material from the leading end of the coil is automatically scrapped during the entry end feed-up operation.

electrical drive system employed. This paper will highlight specific drive features of three of the most recent continuous annealing lines; in fact, they are being constructed at this moment. The general arrangement of the lines, except where applicable to the consideration of the control scheme involved, will not be covered.

The three continuous annealing lines are considered duplicate and, basically, they were designed as such, following the layout shown in Figure 1. These lines are concurrently being installed for U. S. Steel Corp. at the Gary Sheet and Tin Mill, Gary, Ind; at the Columbia-Geneva Division, Pittsburg, Cal., and at the Tennessee Coal and Iron Division, Fairfield, Ala.

It is noteworthy to comment on the excellent planning and detail of specifications, by the engineering groups of the respective mills. As a result a very limited number of electrical drive system changes from the original specifications have been made.

Each line is capable of continuously annealing strip steel, cold reduced to thicknesses from 0.0070 to 0.0150 in. in widths from 22 to 38 in. The lines have a maximum capacity speed of 1500 fpm., with over-speed in the entry and delivery sections to 1875 fpm. It is important to note that strip storage capacity during coil changes is sufficient to maintain top annealing section speed.

One of the features of these lines is the degree to which strip feedup has been automated in the entry section. As seen in Figure 2 (auto feedup system), the basic line arrangement consists of two passes, one leading from each uncoiler to the welder. Three sets of pinch rolls, two for the upper pass, perform the actual strip advance function, and each consists of two rolls. One roll, driven from an a-c gearmotor, feeds the strip when in the closed position. The other roll is driven by a d-c helper motor, and operates only with the pinch roll open, acting as a driven deflector roll during the line run condition.

One of three annealing lines is designed to handle scrap from the new coil by a d-c motor-driven, center-wind scrap coiler, one for each uncoiler. The operator manually inserts the leading edge of the new coil in the first pinch roll, closes the pinch roll and pushes the automatic scrap control pushbutton. From this point on, the strip is automatically handled up to the welder. A deflector gate opens, the scrap reel accelerates, and the pinch roll moves the strip forward until there is sufficient wrap on the scrap mandrel to allow the scrap reel to pull the strip. At the same time, a contact gage is inserted and assumes control, and the pinch roll is opened. Off-gage strip is automatically wound on the scrap reel, until it either becomes on-gage or until the operator has wound as much as desired by means of a gage by-pass switch. The scrap reel then automatically stops, the pinch roll closes, and the strip is sheared. The remaining scrap is then wound, while the deflector gate closes, and the strip is advanced. A photolimit switch and pinwheel timer accurately measure the strip to advance it up to the welder, where it is then ready for the next coil change.

Similarly, when the entry end is stopped, operation of the welder shear automatically initiates retraction of the tail end back to the deflector gate, where it reverses and is wound on the scrap reel. Likewise, when the operator has clamped the new leading edge in the welder, the weld cycle is completed and the entry end is accelerated automatically.

The other two annealing lines are automated to the degree that scrap is chopped by a rotary shear, but not wound as a coil. The amount of initial strip scrap is controlled by the operator.

Any increase in efficiency of the coil changeover at the entry section, as described, is critically important

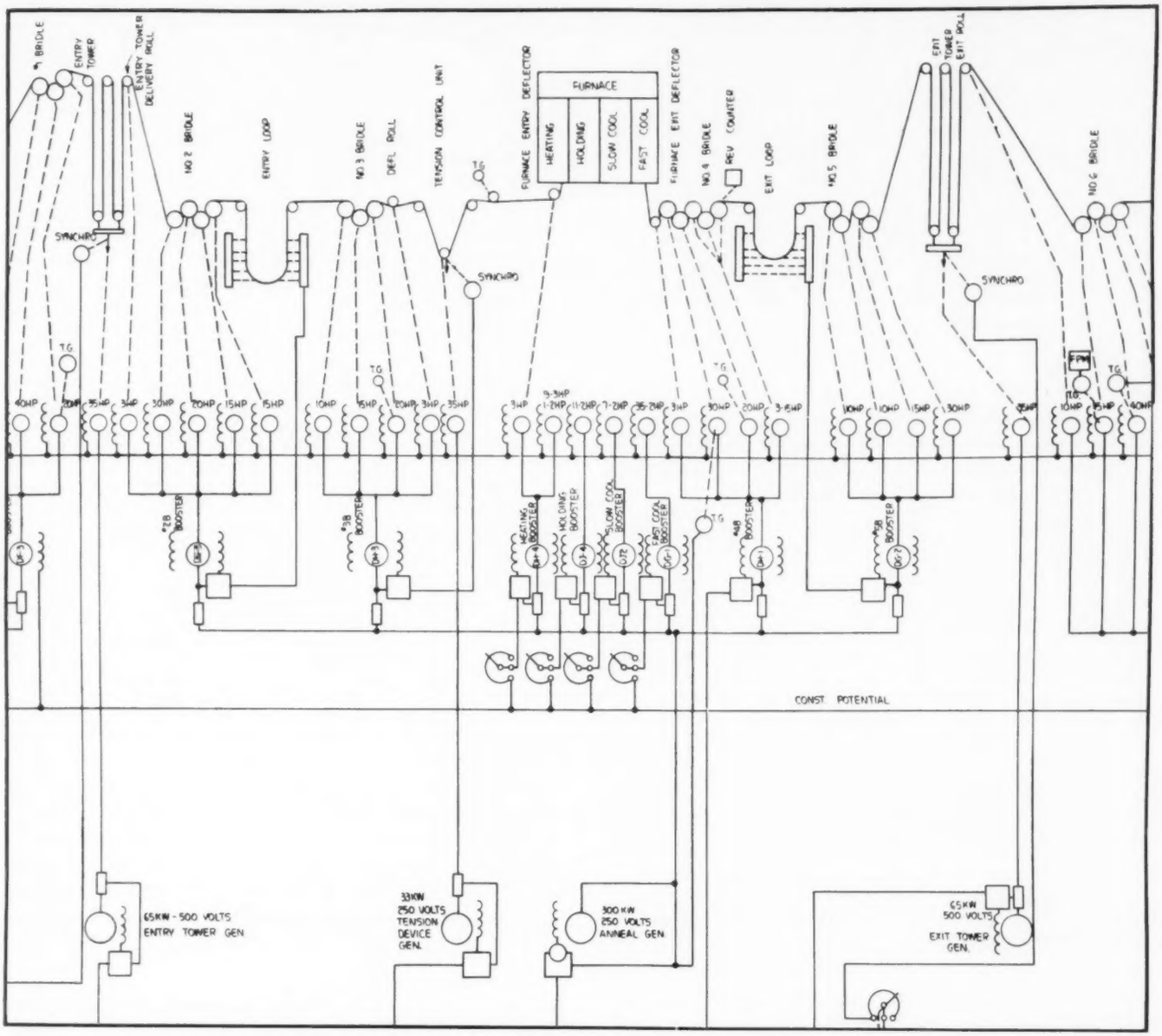


Figure 3 — No. 4 bridle drive motors provide the pace for the entire line and provide fixed speed reference for the annealing section.

in maintaining furnace section line speed, when determining loop tower storage capacity.

Note the over-all configuration of the line, shown in Figure 1. Notice that the annealing or main section of the line includes all the equipment between the entry looping tower and the exit looping tower. Figure 3 details the line flow and single line control system in this section.

The section receives variable-voltage power from the main furnace generator. Specifically, the pace-setting group for the entire line are the motors which drive the No. 4 bridle. This bridle is individually controlled through a booster generator, and is speed-regulated to provide a fixed speed reference for the annealing section. The more than 60 helper roll drives in the furnace proper are performing their intended function; to provide accelerating and decelerating power to overcome roll inertia, and to overcome running losses in order to maintain the desired strip tensions in the furnace.

The original concept of the line had placed the exit storage tower following the No. 4 bridle, with bridle No. 5 pulling out of the tower, and isolated by a free hanging loop between the No. 5 bridle and the delivery end drag bridle. This arrangement was designed to eliminate tracking problems in rewinding due to tension effects from the tower. Such a scheme undoubtedly contributed to the desirability of placing the furnace tension device ahead of the furnace, to absorb tension transients through the annealing furnace. The furnace tension device consists of a short loop provided with a loaded roll, driven vertically by a regulated torque motor to establish tension. The position of the roll, in turn, modifies the speed of the No. 3 bridle ahead of it.

However, the final design brought the No. 5 bridle ahead of the exit tower, and the free loop between it and the No. 4, or lead, bridle. The primary consideration, therefore, was to exclude all external tension transient effects from the annealing furnace where tension is critical. It then became the contention that elimination of the furnace tension device entirely, and control of furnace strip tension by current-regulating the No. 3

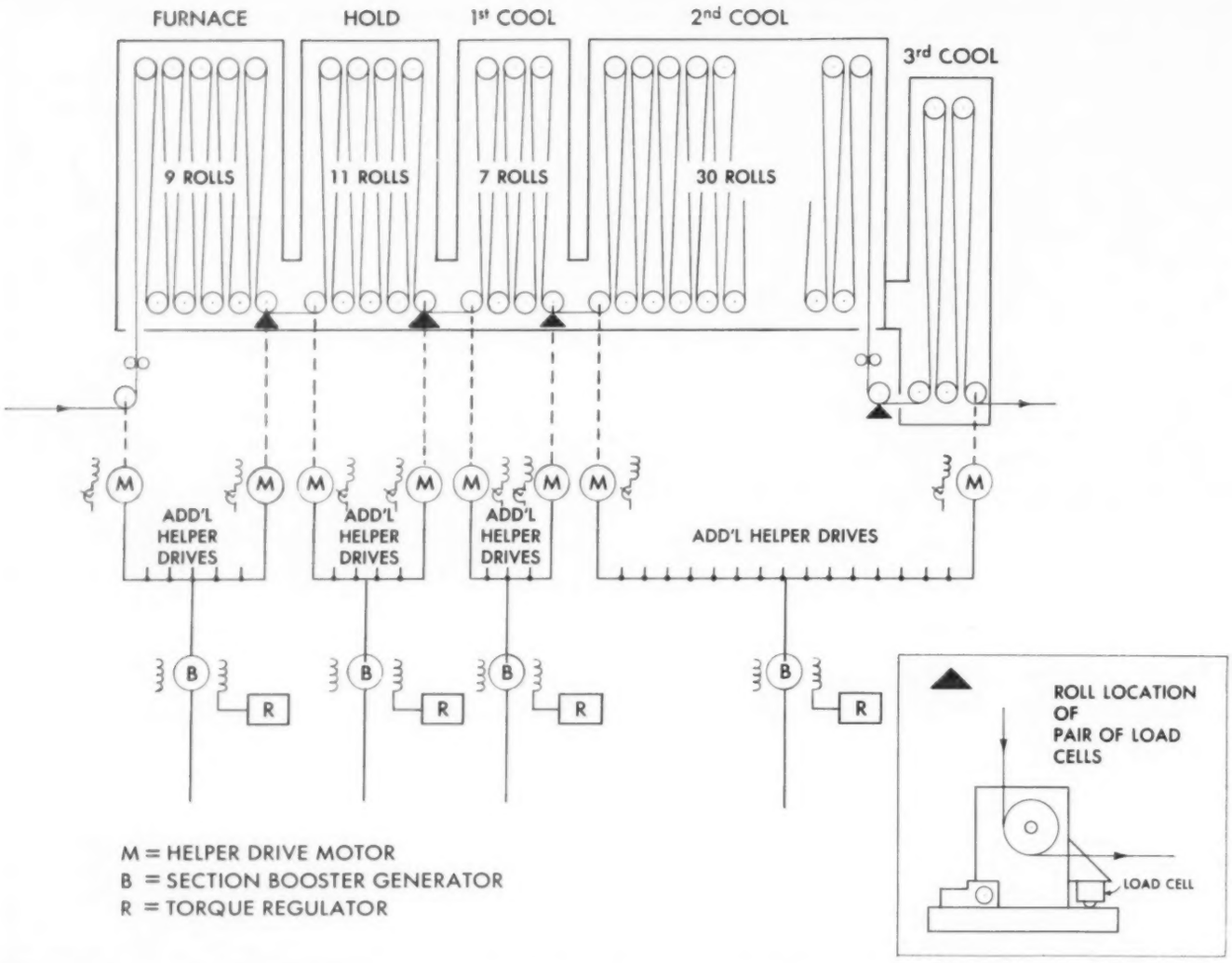


Figure 4 — The furnace section contains more than 60 helper roll drives and four strain gage load cells which assist in controlling furnace tension.

bridle, would provide the best means to insure constant tension through the furnace. The variables present in tension control with the loop tension device are numerous compared to tension-regulating the No. 3 bridle directly. Consideration must be made for acceleration of the roll in the tension device by the strip, compounded by the time delay in acceleration of the No. 3 bridle, after a change in position has occurred. In addition, the operating range of the tension device is quite limited.

Not being permitted to eliminate the furnace tension device, extra flexibility was designed into the system to allow initial operation with the tension device, and position control of the No. 3 bridle, with the ability to transfer electrical control to tension regulation of the No. 3 bridle and lock the position of the tension device roll.

To further refine the control of the tension in the annealing furnace, extra control features were added to the helper drive system. The ideal arrangement would call for a torque regulator controlling each helper drive motor in such a way that the strip tension on either side of each roll would be controlled. In this manner, the motor supplies exactly the torque necessary to overcome friction, and, during line speed changes, to overcome the roll inertia. Economically, this is prohibitive. But an approach toward this goal was made by the addition of four torque regulators. These are applied to the booster generators that supply each group of helper drives divided according to the functional divisions in the annealing furnace; viz., the heat section, hold, slow cool and fast cool sections. The motors are individually adjusted for load-sharing within each group by their field rheostats.

But providing the equipment to torque-regulate was not enough. It remained to be determined what value of torque was just right. With the cooperation of the furnace builder, four roll locations were selected, as shown in Figure 4, to mount strain-gage-type load cells. Each roll selected is the last roll in each furnace section, and permits progressive tension measurement in conjunction with the grouping of helper drives for control purposes. Aside from the other many mechanical considerations, the furnace roll mountings are designed so that the pillow blocks at each end of the roll are supported at two defined points: one, a fixed point about which there is no resistance to a moment; and the other, the load application point of the load cell.

Thus, the tare weights of the roll and the tension in the strip entering and leaving the roll are resolved into moments that are readily calculated. The electrical

output signals of the load cells are added in series for each pair associated with a roll, amplified, and the values of strip tension recorded on strip charts.

During initial operation of the lines, investigation will be made of the pattern of strip tension through the furnace under various conditions of line speeds, tension setting, and helper drive loading, as it affects strip quality and elongation. In addition, the indicating system has been arranged to provide a d-c output signal that fluctuates about zero for the predetermined normal level of tension. This signal may be utilized as an input to the helper group booster regulating system as a torque vernier reference. Hence, the necessary components are present to automatically control the torque input of the helper drives.

As continuous annealing lines are designed for higher speeds and increased widths of strip, the strip tension and strip propulsion horsepower requirements reach proportions that require the use of multiple roll bridles. Aside from the tracking problems, a physical limit is reached in which the tension gradient through a bridle and the maximum practical angles of wrap exceed the capability of two roll bridles. Various mechanical arrangements are employed to increase the pulling or dragging ability of the bridle, such as the application of pressure rolls, and by mechanically varying the configuration of wrap. These methods are usually accompanied by tracking problems.

Electrically, whether a two-roll or multiple-roll bridle is involved, the basic problem is load-sharing in the proper relationship between the motors driving each roll. While there is no question as to the superiority of individual roll drives, the load-sharing becomes critical when the bridle reaches its maximum tension capacity and the slip points for each roll are reached. Any tendency for one drive motor to assume more of a load may result in slippage on that roll, which immediately causes slippage on the other rolls, and resultant loss of tension.

In the case of two roll bridles in which the mechanical slip points are not approached through the range of tensions, it was adequate to permit load-sharing by the inherent regulating characteristics of d-c stabilized shunt machines; normal compound in the order of 8 to 10 per cent. More sophisticated arrangements provide additional field excitation by paralleling the series field across an armature-dropping resistor, which causes the more heavily loaded motor to try to drop speed and relieve itself of load. Another method is to cross-compound the two motors, so that an increase of load on one motor will over-excite a differential field in the other, and thus shift the load.

But with multiple-roll bridles that require closer control of load-sharing to avoid slippage, a system is needed to quickly restore load balance by direct action on the overloaded motor, as well as the other motors in the network, which must assume more load to maintain constant tension.

The first consideration is the selection of ideal motor ratings, and is the initial concern of the machinery builder. Basically, the difference in strip tension from one side of each roll to the other is developed by the driving or dragging torque of the motor. This torque is imparted to the strip by friction, and is expressed as a ratio of the higher tension on one side to the lower

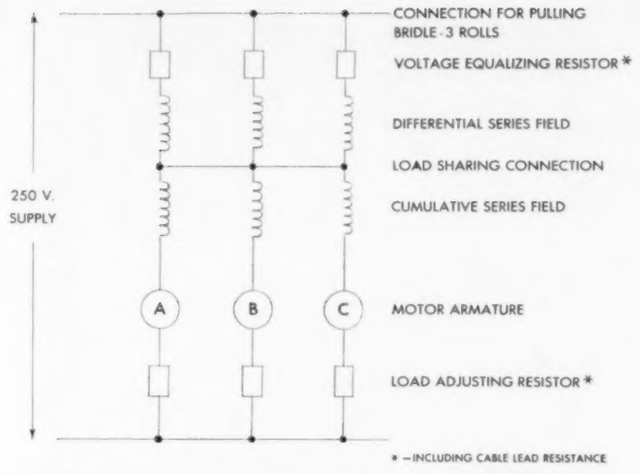


Figure 5 — The three motors driving each bridle are connected in a load sharing network to permit use of inherent regulation characteristics.

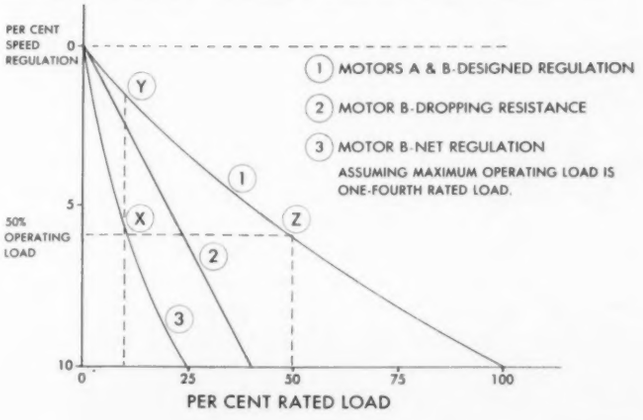
tension on the other side, called "the amplification factor." This factor varies exponentially to the base e as the product of angle of strip wrap in radians, and the coefficient of friction between the strip and roll. Examination of this relationship shows that each successive roll on a bridle, from the low to high tension can handle, before slipping, an ever-increasing build-up of tension. Furthermore, the maximum tension capabilities of a bridle vary greatly with the amount of initial tension available on the low side, as particularly evident for a bridle adjacent to a free-hanging loop.

The rating of each roll drive motor depends on the ability of that roll to add tension to the strip up to the slip point.

It is very important to select motor ratings with the least excess horsepower above the maximum tension requirement of the roll for two reasons. First, the normal running strip tension is often below the maximum tensions designed for a bridle. Second, the load-sharing ability of the bridle motor network depends upon the armature current action through motor series fields, and hence it is desirable to maintain motor loading as close to ratings as possible.

Figure 5, in schematic form, shows the bridle load-sharing network for a pulling bridle. Each motor has dual-series cumulative and differential fields. The dif-

Figure 6 — The curves show the relative regulation required when bridle motors operate at different load percentages though connected together by the strip.



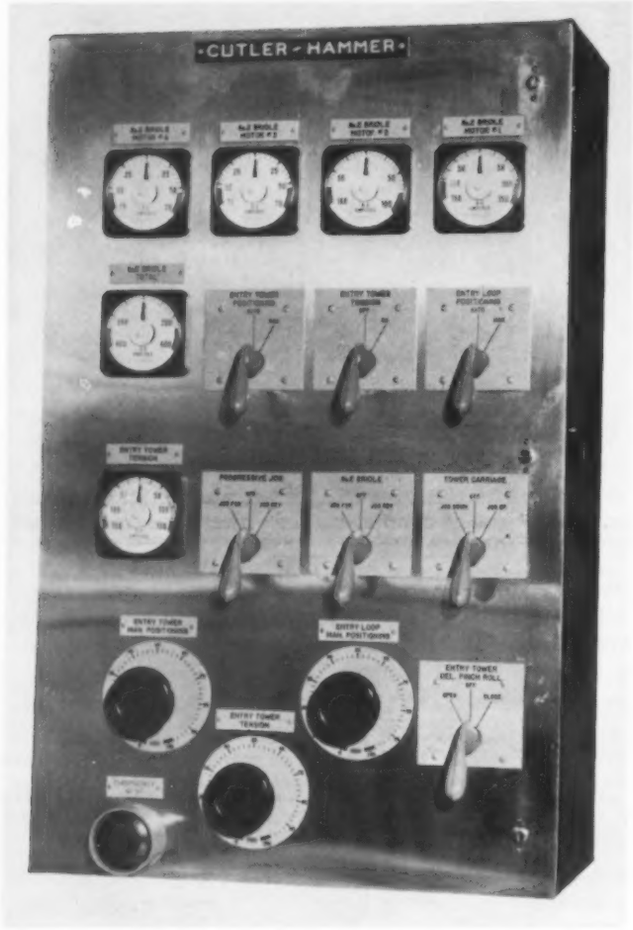


Figure 7 — Entry tower control can be handled from No. 2 bridle operator's station.

ferential fields are connected in parallel, in such a manner that an increase in armature current in one motor will pass through its own cumulative field, and will also be distributed in the differential fields of the other motors.

The various bridle motors are designed for each rating to have inherent regulation characteristics, including the dual-series fields, as nearly alike as practical. Each group of drive motors for a particular bridle is then considered individually in designing the load-sharing network. The requirements for each bridle, as to percentage of motor loading for maximum tension, normal running tension, line speeds and cable lead resistance, are accounted for and the net motor characteristics are resolved by addition of armature resistance. In this manner, each motor inherently will assume its proper percentage of load. To illustrate with two motors, Figure 6 shows per cent of regulation versus per cent of rated load. Assume that motors A and B, with dual-series fields, are designed with regulation of curve 1. Taking an extreme case, assume motor A has a 100 per cent operating load equal to its rating, and motor B a 25 per cent load for 100 per cent operating load. These motors, tied together by the strip, must run at the same speed or slip. Therefore, the regulation curve of motor B must be adjusted by addition of resistance, curve 2 (based on IR drop in the motor B armature circuit), to have a net characteristic of curve 3. Then, for example, if the bridle is running at 50 per cent operating load, the regulation of motor B (point X) will be the same percentage as motor A (point Z), while carrying its proportionate load.

Other factors affecting load distribution must be allowed for. Bridle roll inertias are often equal, and not in proportion to the running load each motor carries. Thus, during acceleration, unbalance of running loads must not exceed slip torque limits of the rolls. Furthermore, the smaller motor ratings on the low tension side of the bridle must have adequate torque capabilities during jog operation for threading of the strip.

Special attention was given to the design of the No. 6 bridle, which during normal running conditions acts as a drag bridle, but after shearing the strip, becomes a pulling bridle. The bridle load-sharing network and motor ratings are, consequently, capable of tension build-up in either direction for the same percentage load distribution, and still remain within the slip point of each roll.

Several other systems on the line are worthy of mention. As part of the strip break-detection system, which initiates an emergency line stop, the cleaning section at the entry end is protected by electrical comparison of two tachometers, one driven by a No. 1 bridle motor and the other by a wheelbarrow roll riding on the strip after the welder. An adjustable percentage of line speed difference is detected and amplified by magnetic amplifier, which actuates the emergency stop relay. Similarly, a tachometer driven by a wheelbarrow roll on the entry side of the furnace is matched with a tachometer at the No. 4 bridle, to cover strip breakage in the annealing furnace.

A like system is employed as a coil depletion signal for each payoff reel, by comparison of the voltages from tachometers driven by the uncoilers and a line speed reference tachometer.

The importance of uniform coil build-up and the control of tension during build-up and line speed changes need no elaboration. The design of the recoil regulating system for these lines contains circuitry to achieve the most desirable operating combination. Basically, a two-regulator arrangement controls the recoil motor and individual generator. One regulator properly adjusts the motor field strength during coil build-up, and the other maintains constant strip tension through armature current control of the generator field. The motor field-regulating reference signals are developed by the time-proven tachometer follow-up system, in which line speed is compared to reel speed, and the difference continually adjusts a follow-up rheostat to keep the motor field at the proper strength. In addition, a convenient measure of coil diameter is generated for proper inertia compensation.

The tension-regulating reference is compared to the rewind motor armature current to maintain constant tension. Superimposed on this signal are inertia compensation correction signals, as a function of exit end acceleration rate and coil diameter, to provide the extra accelerating currents required.

To achieve complete flexibility, the means are provided to obtain a current feedback signal for tension control from the armature circuit of the No. 6 bridle. The strong advantage of this technique is the elimination of coil inertia considerations. Only the drag bridle

current must be maintained constant for a constant rewind tension, regardless of coil build-up. Introduction of accelerating currents are known quantities, represented by a No. 6 bridle roll inertias, and to a minor degree the tower carriage inertia, which are fixed. In conjunction with the alternate, a counter-emf regulator controls coiler motor field strength.

Incorporated in the control design is a looping tower position-control system that obviates the use of photoelectric cells, which are often inaccessible for maintenance. The system utilizes a synchro transmitter, which is driven by a low-speed output shaft of the tower carriage drive, through an integral gear reducer. The output signal is fed through a synchro differential control transformer, and then amplified for use as a vernier signal in the entry or delivery generator regulating system. The signal is capable of producing the difference between 250 and 312 volts out of the main generators, for maximum over-speed of the entry or delivery sections.

The synchro system will operate over the full range of the tower carriage travel, 66 ft, which is equivalent to 160 degrees rotation of the synchro transmitter. Full synchro output can be developed in three ft of travel, and carriage position will be maintained within one ft of travel.

Aside from the great advantage of minimizing the position-control equipment required on the tower, the differential control transformer will allow the operator to select any desired operating level in the entry tower. Slowdown and extreme travel limit switches are also provided for protection in the last five ft of travel. Additional synchro receivers operate large dial indicators on the operator's station to give the operator full knowledge of the tower carriage position at all points. The entire system is simple, rugged and flexible.

In conclusion, as product demands bring about the evolution of processing lines capable of greater speeds and capacities, the associated electrical drive equipment cannot merely be increased in size. Old systems are no longer adequate, but must be upgraded to handle the new problems created.

By the exchange of ideas in the electrical industry, and closer cooperation with mills and machinery builders, these problems are more readily resolved.

Discussion

PRESENTED BY

LLOYD H. JOHNSON, Product Section Supervisor, Systems Control Sales Div., Cutler-Hammer, Inc., Milwaukee, Wis.

IVOR C. RORQUIST, Project Engineer, Sheet and Strip Div., Aetna-Standard Div., Blaw-Knox Co. Ellwood City, Pa.

Lloyd H. Johnson: The importance of obtaining higher production rates and improved product quality demands a constant search for more knowledge of the factors that effect these end results. The steps taken on these lines to measure the strip tension in the four sections of the furnace certainly will make valuable contributions to the art of continuously annealing of strip.

Important in attaining high production rates is ease in maintenance and the ability to quickly locate the source of trouble when it does occur. A centralized memory type fault finder panel was incorporated in the control for each of these three lines and 180 contacts will be constantly monitored by this panel. A momentary opening of any of these contacts will extinguish the corresponding light on this panel. If more than one fault occurs at one time, the corresponding lights, and only those lights, will be extinguished providing positive indication of precisely the contacts or devices involved. The individual fault-finding units are of a nonelectronic type utilizing conventional indicating lights.

It is becoming more and more essential in high speed lines of this type to make a complete analysis of the entire system as a single entity. In designing the control and regulating systems for these three lines, such an analysis was made. The interrelation of all the inertias and time constants of the rotating machinery, the rolls, the strip and the regulators was studied and all of these factors were mathematically related to design a regulating system that will assure not only stable drives but a completely stable system.

Ivor C. Rorquist: In general, the lines discussed, embody the latest thinking in high-speed annealing lines with particular emphasis on the attainment of better quality at ever-increasing line speeds.

I should like to point out a number of items, from a mechanical standpoint, that require special consideration when designing high-speed annealing lines.

1. The best and most efficient method of providing coils at the entry end of the line.
2. The quick and efficient removal of scrap both from the coils proper and from the line itself.
3. Adequate strip storage to allow coil charge and discharge without slowing down the furnace speed by the use of adequately sized and properly designed looping towers.
4. The use of six bridles to isolate entry furnace and exit sections of the line from each other, resulting in better control of strip tension throughout the line.
5. The use of multi-roll bridles to reduce a minimum strip tracking problem as well as special equipment to control, to the closest degree, the tension of the strip as it enters the furnace and the use of helper drives on all rolls with the exception of very small diameter rolls.

As you know, these lines were designed for a maximum width of 38-in. material and 1500 fpm through the furnace. However, we have since designed lines for wider material and speeds in excess of this. It can be seen that the trend today is toward higher capacity annealing lines. ▲

Progress Report on

EARLY in 1960 there was considerable discussion in the steel industry concerning the use of a-c powered cranes. Much of this discussion centered around the specification by the United States Corp. of a-c powered cranes for a new mill at Gary. As a result, the AISE Standarization and Research Committee decided to investigate the need for a standard a-c line of crane motors. Accordingly, the Sub-Committee on Mill Motors held a meeting in April, 1960, at the AISE headquarters in Pittsburgh, Pa.

Interest in this subject was very keen as evidenced by the fact that 25 persons attended this meeting. Eight steel companies and eight motor manufacturers as well as crane manufacturers were represented.

The meeting defined the pressures which existed towards developing a change in a-c crane motor design and characteristics. First, the ever-increasing need to reduce both initial and operating costs can hardly be ignored by any steel manufacturer. The possibility of eliminating the initial costs of a-c to d-c conversion equipment together with a complete d-c distribution system is an attractive lure. The possibility of the reduction of operating costs due to the absence of maintenance on a-c to d-c conversion equipment and an expected lower maintenance cost with a-c drives are also important.

Second, the emergence of safe, precise and dependable a-c control for cranes has lent reality to the possibility of obtaining these cost reductions.

Third, the trend toward smaller design margins in current a-c motor production together with less mechanical huskiness and protection from undesirable environments in these motors caused steel industry users to feel that they were becoming inadequate for steel mill crane applications.

In this connection it is realized by the users that stiff competition results from a desire of many machinery manufacturers to cut their costs. This desire stemming from the ultimate user, puts pressure on the motor manufacturers to reduce their manufacturing cost. In addition, the emergence of better steels, better insulation and more efficient designs has also caused present a-c motors to look less husky.

Also it must be remembered that in a steel mill, the electric overhead traveling cranes in many cases are production bottlenecks. One motor on one crane can shut an entire plant down, therefore, the concern of the steel industry users is understandable.

It was also the consensus of operating personnel of the committee that a-c crane control has advanced more rapidly than the design of the motors for crane service.

At the initial meeting of the committee it was decided unanimously to try to establish standards for a new line of a-c motors for both crane and mill use. In view of this decision a statement of policy was then developed concerning the scope of the proposed standardization. It was stated that the interest of all would be best served by having as little standardization as possible limiting such standardization to those items affecting interchangeability. In this way competition and progress would not be stifled. In general it was agreed that standardization would take place in the following areas:

1. Capacity ratings—speed and temperature rise—enclosure.
2. Mounting dimensions—shaft heights—shaft size—shaft extension—over-all volumetric dimensions as referred to the mounting dimensions.
3. Primary and secondary voltages.
4. Brush size, shunt type—length and bearings.
5. Torque, over-speed, and electrical characteristics.

During the discussion concerning the above points, the question of a split frame type for the standardized line in preference to a solid frame motor was raised.

Having polled and listed the thoughts and requirements of the 25 persons present at this meeting, several sub-committees were appointed to continue work on this problem until a point was reached where it would be valuable to again have a meeting of the entire committee. A sub-committee was appointed to investigate the economics of a split frame vs solid frame motor. Another sub-committee was appointed to recommend ratings; this committee also was instructed to obtain the thoughts of the mill machinery manufacturers since it was realized that such a standardized line would very likely have an application on mill auxiliaries. The final sub-committee was the motor design sub-committee consisting of the engineering representative of each of the manufacturers together with the chairman and vice-chairman of the mill motor committee.

Since the initial meeting two additional meetings of the design sub-committee have been held and the reports of the committee which was appointed to study the economics of the split frame type of construction and the committee on motor ratings have been received.

The economy of split frame sub-committee, after an analysis of the probable maintenance and initial cost requirements, recommended that a solid frame motor be used in the new standardized line. The analysis indicated that the total costs of the split frame motor with its spares would run between 20 to 30 per cent more than that of the solid frame motor, also with equivalent spares. In addition there appeared to be operating efficiency and maintenance advantages for the solid frame in practically every respect with the possible exception of the time and work required to change the motor versus that of changing the armature only. This departed from the thinking of the steel mill users group when the d-c mill motor was developed. It must be remembered, however, that the a-c motor is quite different from the d-c mill motor where armature failures are much more prevalent than field failures.

After the report of the sub-committee on motor ratings, and much subsequent discussion concerning economy for both users and manufacturers, by the de-

AISE Standardization for A-C Motors

by M. B. ANTRIM, Chairman
AISE Mill Motor Committee

This report was presented before the 7th Biennial Materials Handling Conference, Pittsburgh, Pa., October 21, 1960

sign sub-committee, the following ratings were tentatively established:

Hp	*Ratio to next lower hp*	*Rpm*
5	...	1200
10	2.00	1200
20	2.00	1200
40	2.00	1200
60	1.50	1200
90	1.50	900
125	1.40	900
150	1.25	900
200	1.33	720
250	1.25	720

It was decided that the above ratings would be based on a one hour totally enclosed non-ventilated, 85 C rise by resistance and the consideration of other time, enclosure, and ventilation ratings would be postponed until design was further along. (It should be pointed out here that this temperature rise is equivalent to the 75 C rise by thermometer on which the d-c mill motor is rated.)

The design sub-committee has established several other tentative rules.

The maximum breakdown torque of the new standardized line should not be less than 325 nor more than 425 per cent at rated voltage and frequency.

National Electric Manufacturer's Association (NEMA) standards were agreed upon for variation from rated voltage, variation from rated frequency and the combined variation of voltage and frequency. NEMA's standards for high potential test requirements were adopted.

Primary electrical characteristics were selected at 440 volts, 3 phase, 60 cycles.

Tentative secondary voltages have been selected in accordance with existing and proposed NEMA standards.

A tentative time constant has been selected which will give an acceleration rate which will enable the motor to reach 100 per cent speed at rated torque in as short a time as possible but not to exceed 0.7 sec with no connected load for all ratings. This constant is 0.3 sec on the AISE d-c mill motors, but it must be remembered that the rated speeds for d-c motors are much lower than those proposed for a-c motors.

Tentative shaft sizes have been selected for the ratings mentioned before. Same sizes as those on d-c are used but not necessarily on equivalent frames.

Tentative bearing arrangements have been selected together with their sizes. Tentative frames have been proposed for the ratings noted.

At the present time the design sub-committee has reached the point where it would be desirable to have a meeting of the entire mill motor committee. This was scheduled for November 15, 1960. It is hoped that either approval or suggested revisions can be obtained for the work which has been done so far on the preparation of this new standard line of a-c wound-rotor motors. In addition, considerable discussion has evolved concerning over-speed requirements which now vacillate between 150 and 200 per cent over-speed. It is hoped that a meeting of the entire committee will settle this question.

The work of both the main committee and the design sub-committee, to date has gone very smoothly and all of the committee members have been most cooperative. It has been very pleasant to work with them.

This brief report outlines the reasons why a new standardized line of a-c wound-rotor motors for steel mill use have been considered necessary. Although, we in the steel industry feel that this new line of motors is a necessity if alternating current is to be used to any great extent in operations, it must be realized that there will be much inertia to overcome in applying a-c equipment to applications which have since time immemorial been supplied by d-c equipment. This will happen even though the new standardized line represents everything that a steel mill user could want in the way of strength, torque and low maintenance.

It is therefore important that each of the motor manufacturers sincerely evaluate their respective economics in the adoption and production of this new standard line of motors. The steel users will need the enthusiastic support of the motor manufacturers in order to equip steel mills with a-c cranes and mill auxiliaries. If this is possible, this project will be successful and will become a real contribution to both the steel and electrical industries. ▲

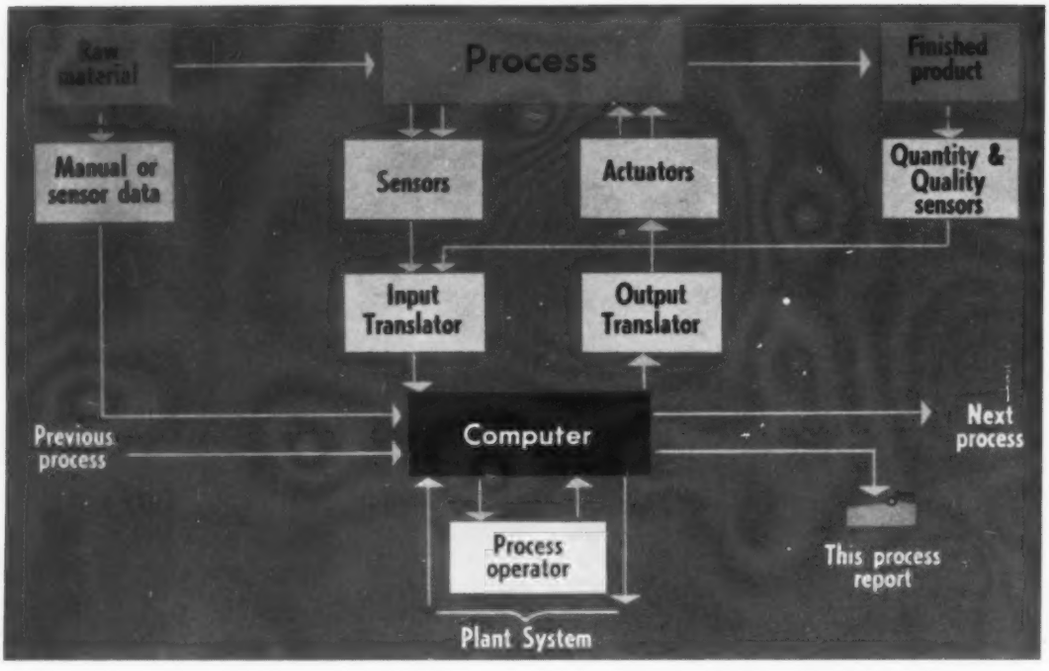


Figure 1 — Simplified block diagram shows digital control computer.

by R. W. KIRKLAND, Steel Mill Application Engineer

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TECHNICAL progress, like sin, appears in different forms in different periods. Today, the beginning of a new decade, progress has appeared as a new breed of digital computers, specifically designed for on-line operation with industrial processes.

The first of these machines was applied to a petroleum refining operation in 1958. Today there are over forty units being built or installed in various industries. Nine of these are for the steel industry.

The continued growth of on-line digital control computer systems is probably assured. Their short but active history indicates that they are filling recognized needs.

The economic justification for control computers is proving to be somewhat easier than for conventional automation equipment. Since they possess the ability to perform a number of operations and functions on a time shared basis, the resulting accumulation of a number of small savings and earnings can be substantial. The versatility of these machines also permits a number of different departments and budgets within a steel plant to share in the advantages and costs.

The rate of growth of on-line computer systems is impressive. It has been so rapid, in fact, that there has been little or no feedback on the problems encountered and the results obtained.

The abilities of digital computers should not be overestimated. Their future use can be made less painful and more profitable if those concerned with their application will regard these machines as production tools. They are new, they are strange. They have certain unique capabilities and they have very definite limitations.

WHAT IS A DIGITAL CONTROL COMPUTER?

Computers are calculating devices. The book description of a digital computer is "a calculating device using numbers to express all the variables and quantities of a problem."

Probably the oldest recognized digital computer is the simple abacus. This primitive model used (and uses) beads strung on a wire frame to represent the numbers in a problem. It was widely used by both the Romans and the Chinese over 2000 years ago. There have been few advances in principle since that time, though there have been dramatic advances in hardware and technique.

The first electronic digital computer did not appear until after the end of the second world war.

Many improvements have been made in the past 15 years.

Today, digital computers of advanced design are a vital and permanent part of industry's accounting systems. Take a look at your next pay check, changes are 99 to 1 that it is a punched card form prepared by some type of digital computer.

Process control digital computers are direct descendants of the business and scientific computers developed in the past decade. The invention of solid-state electronic components and memory devices made it possible to design a practical digital computer, small enough, cheap enough, and reliable enough, to operate continuously around the clock.

While there are many types of digital computers, one general breed is, at present, being manufactured

Application of Digital Control Computers To Steel Industry Process Control

Few developments have had as much interest as those in the computer field . . . . . improvements are on the way and present limitations will undoubtedly disappear.

for on-line industrial use. This type is known as a general-purpose stored program digital computer. "General purpose" because these machines are designed with sufficient flexibility to be used for many, rather than one, specific purpose.

"Stored program" because its operating instructions are read in and retained in the machine's internal memory. These instructions may be easily modified without physical change to the computer.

On-line digital computers are work horse versions of their business and scientific counterparts having the specific characteristics needed by their particular industrial role.

What are the differences?

Physical construction—On-line computers are physically more rugged than business machines. Their cases are heavy, dust-tight, and usually contain filters and air conditioning equipment required to permit the computer to survive in a factory atmosphere. Their components are also operated at only a portion of their rating to improve reliability.

Reliability—On-line process control computers, above all, must be reliable. Reliability, on any machine, is inversely proportional to the number of components. On-line computers are, consequently, as simple as they can be. Many of the convenient circuits and features found on business machines that facilitate programming have been eliminated. On-line computers, as a result, are rather hard to program. This is probably not too serious a sacrifice since such machines will usually run for many years on one program.

Slower operation—Speed of operation is less important than reliability. Business machines were invented to save time, but on-line control computers operate in real time, on processes that are comparatively slow. We shall see later that speed, even in on-line computers, is important; but here we are speaking only in terms of comparative speed among types of computers.

System compatibility—Control computers must be connected to industrial processes by sensors and actuators. They must operate that process. On-line control computers must therefore be designed to coordinate with a wide variety of special purpose input output equipment over and above the typewriters, tape punches, etc., that are provided for scientific type machines.

THE DIGITAL COMPUTER AS A SYSTEM

A digital computer works only with numbers. These numbers may be expressions of miles per hour, hours, temperatures, etc. A digital computer can be connected to an industrial process, such as a rolling mill, and it can control that process. To do this, however, the signals given the computer, by the process, must be converted to numbers. In turn, the decisions and actions of the computer must be converted from numbers into analog signals, contact closures, etc. Thus, an industrial computer cannot work alone. It is only one of the significant components in a larger computer control system.

The characteristics of the central computer determine the performance of the system. In any reasonably complete control system, however, the computer itself may represent a minor percentage of the over-all cost.

A digital control computer must have a translating unit, to convert input process signals into numbers and output decisions into analog signals, plus all the sensing devices, card readers, manual stations and actuating devices required to permit the computer to sense the process and to direct it. Figure 1 is a crudely simplified block diagrom of such a control computer.

WHY ARE ON-LINE DIGITAL COMPUTERS USED?

These production tools are used:

1. To improve process production and quality.
2. To reduce process operating costs.
3. To make some processes possible.

The first two reasons are classic and, though shopworn, will always apply whenever one asks "will it pay?" The last is a new concept. It, perhaps, does not apply too well to today's steel industry problems, but may apply the day an attempt is made to design and operate 10,000-fpm tandem mills or some other type of new and advanced process.

Human operators are comparatively slow and easily confused control mechanisms. No amount of training or experience can completely eliminate basic human frailties. The operating program of a computer however, can be prepared in a methodical, leisurely manner. The computer thereafter will faithfully obey its instructions, undisturbed by noise, fatigue or decision strains. The advent of the on-line digital control computer should spur the development of new, efficient processes.

HOW DOES IT WORK?

The on-line computer is married to the process by the systems' sensing devices, control stations and actuating mechanisms.

Stored within its memory is an instruction program telling it what to do at any instant in time, in all foreseeable circumstances.

Doggedly and blindly following its instructions, the computer scans each input in a definite sequence, or, as in the case of some pulse type inputs, on demand. At each analog input point, the computer scales and converts the signal to a number representing its value in the proper engineering units. This number is then stored in a selected place in the computer memory, replacing any previously entered number. Digital type inputs are read and stored directly.

The data collected by this read-in operation are acted on as required by the program. If high and low limits, for example, are specified for any particular input value, these limits are compared to that input value as it is read. If these limits are exceeded the computer will act to notify the outside world. If the computer is designed to hold a certain signal to some prescribed value, it will compare the input signal to that prescribed value. If there is an error the computer will calculate a digital command to correct that error. This digital command is then converted to an analog signal in the input-output unit and transmitted to the appropriate analog type regulator or actuating device.

If its program so requires, the computer will, periodically or on demand, carry out complex calculations to develop a new set of operating conditions for the entire process.

The computer, on demand, or at preset intervals of time, can perform calculations, using the latest data stored in its memory, and drive electric typewriters or tape punches to prepare reports on process operating conditions.

In the event of an emergency in the process, a command signal, or other sort of nonperiodic interruption, the computer will, following its instructions, either drop its routine cyclic operation to act on the emergency, or it will hold the interrupt action off until it finds time from its routine chores to take the required actions (depending upon the program).

The point to remember is that the computer is an electronic slave that does what it is told to do within the limits of its design capability. The instructions stored in the computer memory precisely determine its actions and reactions. A digital control computer cannot perform *any* operation or control *any* process until that operation or process has been reduced to mathematical and logical terms in a computer program. A digital computer is a very fast, and a very single minded controller.

FUNCTIONAL CHARACTERISTICS

The foregoing has described in somewhat simple terms how an on-line digital computer goes about its job. From this one can see that there are certain functional characteristics to be considered before applying a computer to an industrial process. These are limiting characteristics; if they are ignored, an installed computer control system may do all the things that it is designed to do, but the installation may be a failure, nevertheless.

There are four basic limiting characteristics:

1. *Speed and time*—A digital computer can perform only one operation at any instant in time. The computer's operations are performed sequentially, one

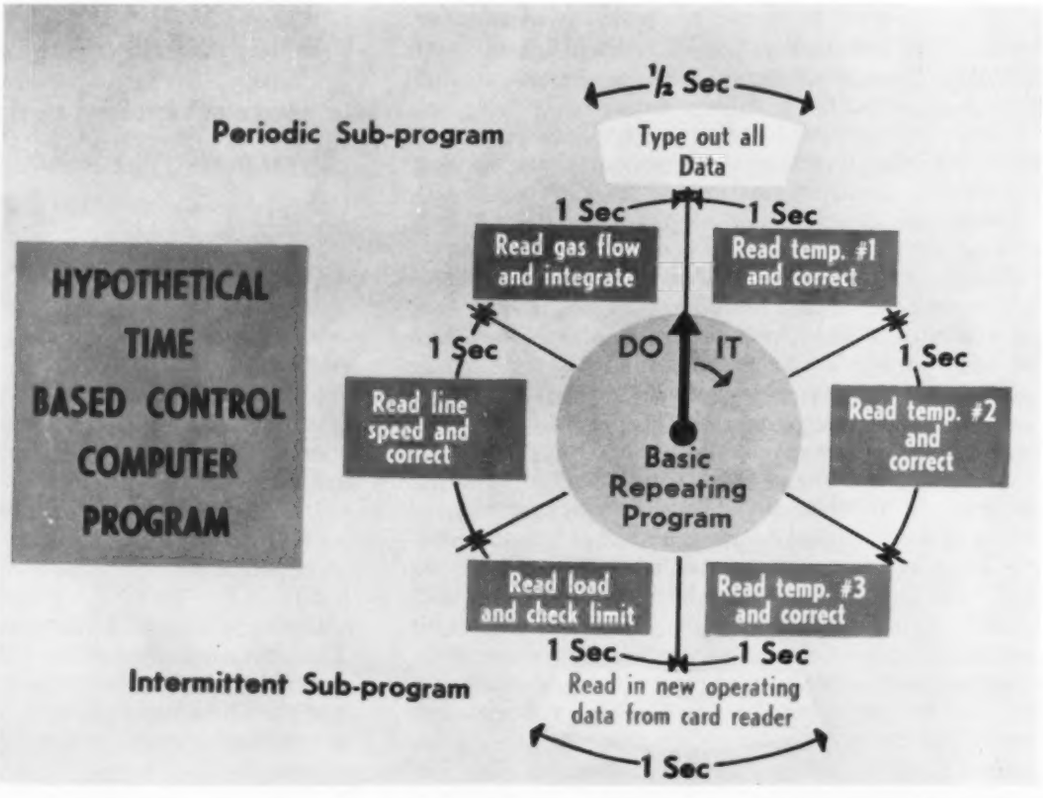


Figure 2 — In this hypothetical program there is a 7½ second interval between the times that operations are repeated.

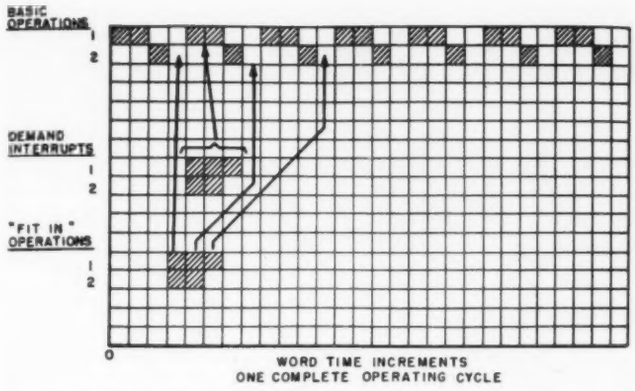


Figure 3 — Chart represents computer operation by word times in program cycle.

after the other. Now, modern digital computers are very fast. Their speed is much higher than the operating speed of the output devices, such as typewriters, valve operators or motor controls. They can intermix portions of many actions, and appear to be doing many things simultaneously. This is an illusion.

It is difficult in the early stages to estimate accurately whether or not the computer is capable of performing all of the desired operations in the time available. In many cases this cannot be known until the computer's initial program is completed. Problems are most apt to arise when the computer is required to perform rigidly timed cyclic operations, and is also expected to perform complex actions at random intervals. The computer can handle only *one* operation at a time.

Figure 2 is a graphic representation of a hypothetical computer program, in time. From this we can see that though many small operations within the program may be performed very quickly, it is, in this case, possible to have a 7½-sec interval between the times that any individual operation is performed.

Figure 3 is another time representation of a computer program. The basic operational time increment of the computer is the instruction word time.

The computer's program is spelled out word by word. In this case we see a program having two basic routine functions, two "demand interrupt" functions and two "when possible" functions.

If both demand interrupts should occur simultaneously we can see that all basic routine functions would be interrupted for five word times. This is a simplified example. In practice such actions would probably require many more instruction words.

2. *Stupidity*—The computer is incapable of original effort of any sort. It does precisely what it is instructed to do though it can be programmed to learn through experience.

The digital computer cannot be used to control or direct any process unless the mathematical model or operation logic of that process is explicitly known and prepared in tedious detail into a computer instruction program. Every conceivable emergency condition must be anticipated. Finally, since all men are fallible, the computer's instructions must tell it how to surrender when confronted with conditions or situations that have not been anticipated in its program.

3. *Signal Noise*—The digital computer does not monitor continuously any one analog signal but samples all inputs at a fixed rate. It will record the value of each signal at the instant it is read. Conventional analog recorders and indicators have enough inertia to damp out a great deal of noise or signal fluctuations. The eye of the observer will average the excursions of the graph, or the indicator needle, to arrive at the mean value of the measured variable. This averaging can be done by the computer, but the requirements of many industrial applications may not provide time for the multiple readings required to average a reading. The input signals fed into the computer should, therefore, be as stable as possible and well shielded from stray pickup. Noise or signal fluctuations that are process generated should be known in advance or anticipated. Crash modifications at installation can be expensive.

4. *Noncontinuous action*—Since all inputs are sampled at a programmed rate, a digital computer cannot provide truly continuous control of any process operation. The response time of any directly regulated variable must be several multiples of the sampling time of that variable if stability problems are to be avoided. This leads one to conclude that the digital computer may only be used to directly regulate very slow processes.

WHAT CAN IT DO?

A digital computer can observe, compare, analyze, and make programmed logical decisions. If provided with the appropriate output equipment it can report, record and act. It can:

1. Collect process data.
2. Count, add or subtract product increments.
3. Solve equations which include any or all of the input data as variables and control the process accordingly.
4. Locate and identify abnormal or dangerous conditions.
5. Alert the operators for appropriate actions requiring judgment beyond its programmed capabilities.
6. Perform a series of routine operations in a precisely programmed sequence.
7. Compute and print out data on the process and its operation, in the forms most convenient for the operators and the factory accounting system.
8. Register and prepare inventory reports on material in process.
9. Classify produced material according to quality and quantity.
10. Prepare summary production reports by hour, turn or day.

APPLICATION CONSIDERATIONS

The following are a few ground rules for selecting applications where the digital computer can show its economic and operational advantages.

1. In control of a process, the computer should be restricted to decision-making functions, and should not be used to regulate directly a process variable. Instead, analog type local regulating loops, receiving command signals from the computer should be used.

2. The computer's ability to prepare accounting data such as pay records, order and stock flow, and

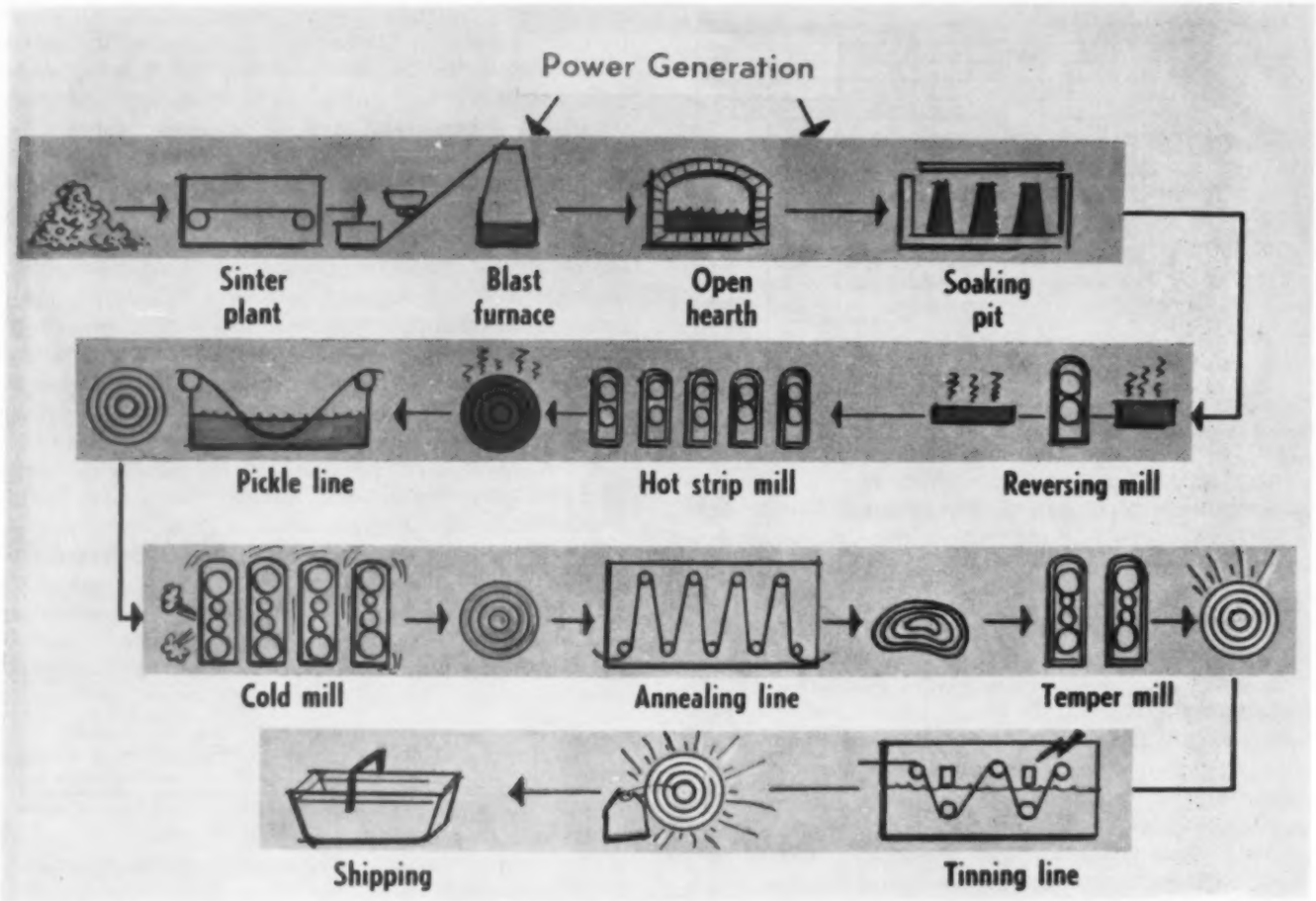


Figure 4 — Almost every process in the steel plant will probably eventually be adapted to computer operation.

utility records should be considered in every application, even though the primary purpose of the installation is for process control. These functions add little to the cost, but often produce large and readily calculated savings.

3. Do not let the data processing functions interfere with the main purpose of the computer, that is control.

SELECTING A PROCESS

A digital control computer cannot be applied to any process that is not economically and physically ready to accept it.

The computer equipment must include everything required to let the computer see, feel and steer the process. If this requires extensive mechanical and electrical modifications the cost can be prohibitive.

Bearing this in mind, as well as the computer's capabilities and limitations, let us list process characteristics to be considered.

The process should be:

1. Continuous, with a high production rate and contributed process value.
2. Mechanically automatic, requiring no manual handling of the product.
3. Fitted with fast accurate regulators on all vital process variables.
4. Complex, having many variables affecting production rate and quality.
5. Operated on proven scientific principles or well defined empirical methods.
6. Capable of improvement.

There are some thirteen basic processes in a modern steel mill producing strip and tinplate. Figure 4 is an example.

In this particular layout only the pickle line and the temper mill would seem to be excluded from present consideration. The pickling process is relatively simple and the increased value of the product is too slight to justify the cost of a computer system. The temper mill in its present form would probably require too extensive a mechanical redesign to permit practical computer control. These processes may be equipped with some sort of digital data processing units to permit automatic collection of inventory and production data when plant-wide automatic accounting systems are developed.

Of all the processes, the continuous hot strip mill and the tandem cold strip mill are the most immediately suitable for computer control. The high production rate and high contributed product value of these lines should provide the economic return required. The extensive work done on automatic gage control systems for these mills also has provided the mathematics and know-how required to develop the computer's instruction program.

The control computer system developed for any process at any plant will reflect the operating practices and procedures followed on *that* process at *that* plant. No two systems will be alike in detail. Time and space do not permit descriptions of the systems being proposed or installed. The coming year should see the publication

of papers describing their design and the results obtained. Rather than speculate in advance of these reports let us list the systems that are now being constructed.

1. *Sinter plant computer logger*—A noncontrolling computer monitoring some 75 analog signals and calculating operating data. Control functions may be added later.

2. *Power plant dispatching computer*—A noncontrolling computer monitoring power and gas flows and continually calculating predicted demand. Visual indication and typed logs for most economic control power system operation.

3. *Continuous annealing line control computer*—A control computer monitoring some 65 analog signals, logging operating data, controlling the annealing furnace, classifying the finished product and directly preparing accounting and inventory records.

4. *Hot strip finishing mill*—A control computer used to calculate and set mill stand screws, stand speeds, automatic gage control reference values and to monitor and log mill output. Incoming slab dimensions and desired finished dimensions are manually set up.

5. *Continuous hot strip mill*—A digital computer for setup of finishing train and gage control system plus setup of roughing train. Order instructions entered through punched tape at reheat furnaces.

6. *Reversing mill (3)*—Control computers used to control the operation of both main drive and edger using the computer to calculate screw settings and speeds for optimum production rates within the ratings of the drive motors. Slab and turn total production data logs are provided.

7. *Continuous electrolytic tinplate line*—A control computer monitoring process operation, controlling plating tank current level and selection for optimum operation.

Studies are now underway to develop computer systems for the blast furnace, the open hearth and the tandem cold strip mill. It is anticipated that active design work in these areas will be started in the coming year.

INTEGRATED ACCOUNTING

All but the smallest industrial plants have developed plant-wide accounting and inventory control systems using digital computers and other data processing machines. Most steel mills have established separate systems and procedures groups to control these operations and to devise methods to improve them.

Accurate inventory control and scheduling are vital to efficient plant operation.

The orderly flow of material from the open hearth to the shipping platform is a planned and scheduled operation. The material in process may look absolutely uniform to the casual observer, although in various lots or orders, the dimensions, analysis and properties, vary considerably. Each customer's order must be scheduled and poured at the open hearth, followed, and given the proper prescribed treatment at each step in its path to the shipping platform. The steel in each order increases in value at every step in the process. It also suffers losses due to cropping, shearing, trimming and accidents.

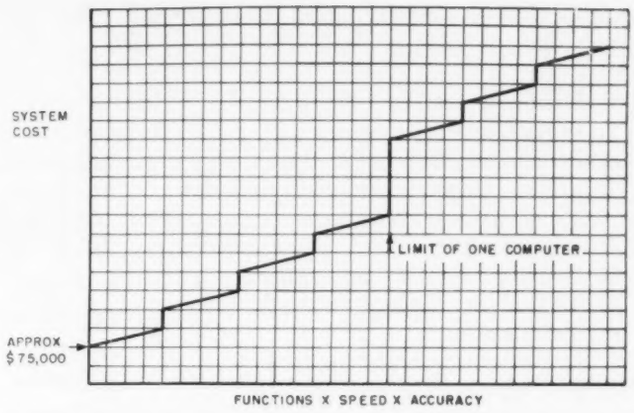


Figure 5 — Cost goes up in jumps as additional system complexity is added.

At present the mechanized operation of order tracking and accounting is based on data manually collected at each process.

This is the weakest link in the chain.

Digital control computers operating on-line at each process are capable of collecting all inventory and accounting data pertinent to each process. The on-line computer can reduce this data, convert it to the desired form and feed it into the plant central accounting system quickly and accurately.

This capability should never be overlooked. Each on-line computer system should be carefully designed to fit into the plant accounting system.

This means also that plant accounting systems should be planned to accept data from the on-line digital equipment.

PLANNING THE CONTROL COMPUTER SYSTEM

A steel mill that needed, say, a new slabbing mill, probably could order that mill with a three sentence specifications. This is possible simply because both users and vendors are thoroughly familiar with the process, the equipment and each other. This is not true with digital control computers. There is little prior experience. The technology is new. Computer specialists do not understand steel mill processes and few production people understand computers.

So for the next few years careful, deliberate planning will be required. The combined talents of both computer specialists and process experts must be used to reduce waste and confusion.

The digital control computer is a machine developed to operate a process. The user must carefully specify the functional operating characteristics he wants in the computer system developed for his process, if he is to retain control of that process.

Computer designers, programmers or other specialized experts must never be permitted or required to determine the operational features of the system.

A programmer or computer designer confronted with a problem will solve that problem in the simplest or most efficient manner from his own point of view. This will seldom be the best solution for best operation of the process.

The application of a digital control computer should follow a deliberate, careful procedure that allows

ample time for each phase. Here is one suggested program.

1. Define objectives
2. Form application group
3. Preliminary process study..... 6 to 12 weeks
4. Prepare preliminary functional specifications..... 2 to 4 weeks
5. Select vendor..... 2 to 4 weeks
6. Prepare detailed specifications....12 to 24 weeks
7. Manufacture equipment
8. Train personnel } .....12 to 14 months
9. Install computer
10. Evaluate results } .....12 to 24 weeks

These steps are fairly straightforward but a little explanation may point out the importance of several of these.

1. *Objective*—First one must decide what the principal purpose of the computer system is to be, i.e., is it to control the process, or to collect production or accounting data? This is important, since later developments may require that certain functions have to be assigned operational priorities.

2. *The application study group*—Digital control computers can be accounting machines as well as production tools. The design of the system will require the cooperative efforts of production, accounting and engineering people. The group should, if possible, include a computer and process instrument specialist to keep the group's plans and decisions within reason. The primary objective should be considered at all times if the final system is to avoid resembling a camel (which has been described as an animal that looked like it had been assembled by a committee).

3. *Preliminary process study*—The process to which the computer system is to be applied should be carefully defined. The limits of computer operation must be established. The existing equipment and components must be critically evaluated and the devices needed to complete the system estimated.

The operation of the process must be described, analyzed and changed where needed to provide greater efficiency and system simplicity. The data accumulated here will provide the basis for the preliminary system design.

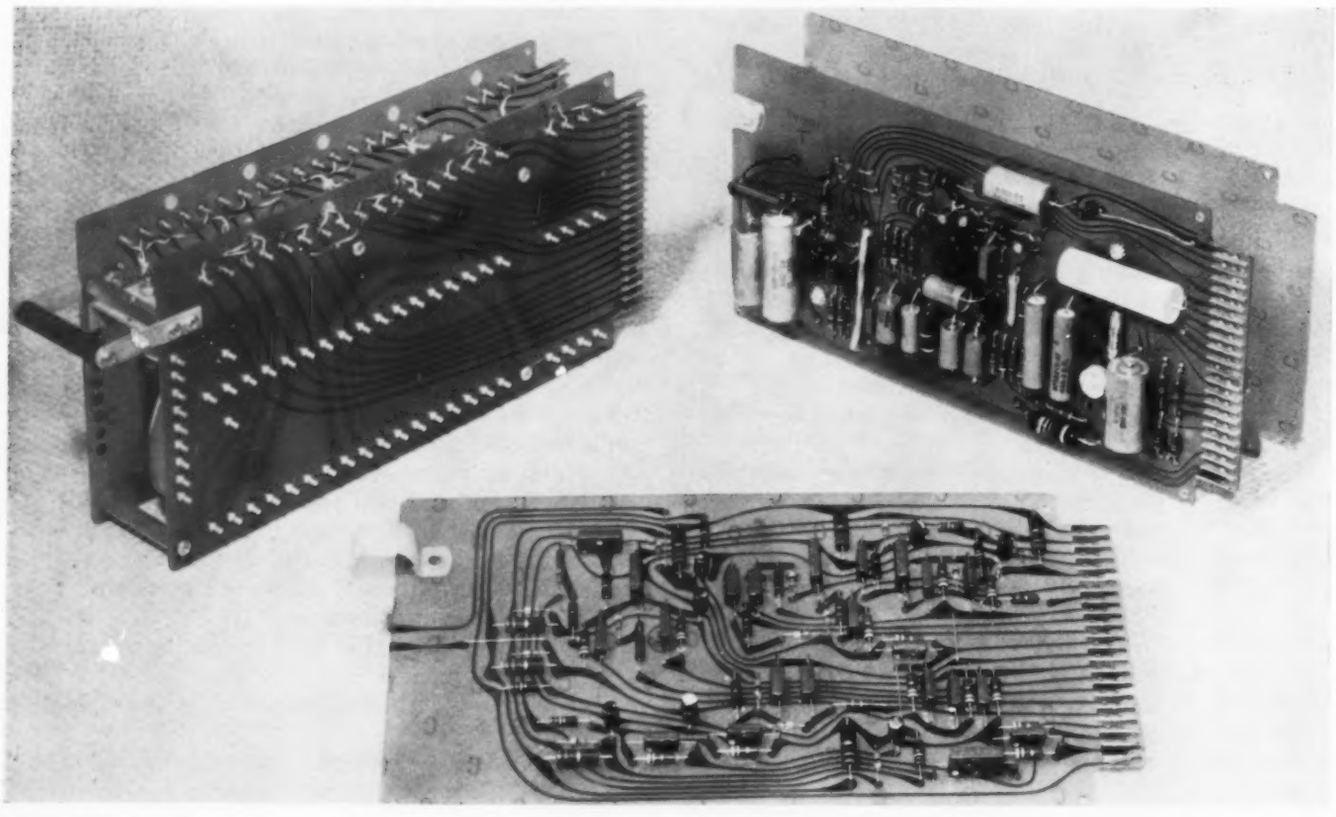
4. *Preliminary specifications*—The preparation of specifications that are clear and adequate is an art. Preliminary specifications are prepared to permit prospective vendors to engineer bids that are accurate and comparable, reflecting similar bills of material and labor. These specifications should be functional, describing what the computer is to do, when it is to do it, how frequently and how accurately. The hardware required to satisfy these requirements is properly left to the ingenuity and technical competence of each vendor. Manufacturers are eager to supply the best possible system. The user can help by being as clear as possible about *what* is to be done—not *how*.

These preliminary specifications need not describe every detail of the final system.

The most economical system will be obtained when the final design is worked up through cooperation with the successful vendor, considering the characteristics of his computer design.

The cost of a digital control computer is related to a factor including functions, operating speed and accuracy requirements. Computer systems today are built up of modules. Consequently the cost curve is apt to have a number of step changes as modules are added to com-

Figure 6 — Low power levels are a feature of computers.



plete the system (Figure 5). Frequently the elimination of a minor function can save considerably more than the function itself is worth.

It is worth mentioning here that sufficient time should be allowed for the vendor to do the basic engineering required to evaluate all requirements and develop reasonable cost estimates.

5. *Selecting vendors*—After bids are presented by prospective vendors the buyer is faced with the problem of evaluating the various proposals. This can be an extremely confusing ordeal. Often as much time is spent in this phase of the program as in the previous stages combined. This is understandable, competition is keen, the proposals vary widely in price and type of hardware. The user is faced with the necessity of determining which proposal is best for him while surrounded with conflicting arguments and claims.

Each user must decide, measuring all claims and proposals against the yardstick of his own peculiar needs. Some valid factors which have been used for comparison are:

The System

Price.
Specification agreement.
Type of memory system.
Operational speed.
1. Clock frequency.
2. Add time.
3. Multiply time.

Number of instructions.
Input scanner type.
Quoted scanner speed.
Type of construction.
Rating of components.

Figure 7 — Modular design is also typical of computers.

Diagnostic programs provided.
Maintenance programs provided.
Cost of spare parts.
Quality of peripheral equipment.

The Vendor

Computer application experience.
Steel mill process experience.
Process and system analytical assistance.
Service organization.
Program library and assistance.
Customer training facilities.

The weight that each user will apply to each factor, or the other factors that might be considered, will vary depending upon the user's estimates of his own needs and the particular vendors being considered.

The prospective user should not however become so engrossed in the details of the computer itself that he loses sight of the fact that it is but a part of a system. The world's crudest computer, properly fitted into a well conceived system will out-perform the most sophisticated computer fitted with hastily selected input-output equipment, sensors and actuators.

There is another factor that must be carefully considered. Is it compatible with existing and future automation systems? Expensive future modifications may be required if each process control computer system is specified and designed without considering how it is to communicate with the plant's data processing system and other process control systems.

INSTALLATION OF SYSTEMS

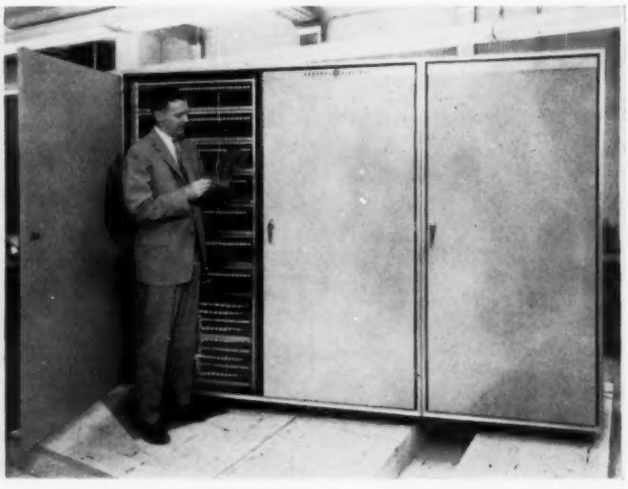
All modern digital computers use the latest semiconductor devices. These components operate at very low power levels. Figures 6, 7 and 8 are illustrations of a typical digital computer and its components.

The computer system must be protected from stray magnetic and electrostatic fields. Otherwise its components and its operations are apt to be periodically and mysteriously affected.

This is a subject that could cover several pages. Here are a few rules:

1. Do not install a computer cabinet near transformers, high tension cables or magnetic control panels.

Figure 8 — Maintenance is simplified by ability to replace components.



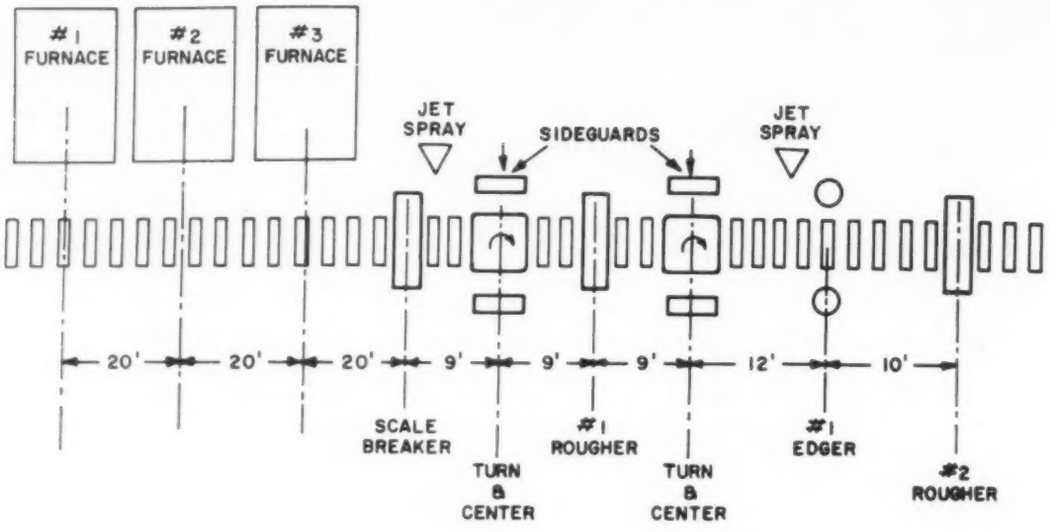


Figure 9 — Block diagram shows elements which must be controlled in roughing mill.

2. Provide a separate ground system for the computer system.
3. Use shielded protected conductors grounded at one end only for all low level sensing devices.
4. Do not run computer system wires in conduit or racks near power wiring.

DESIGN SPECIFICATIONS

Final design specifications should be prepared jointly by the user and the manufacturer's systems engineers. These specifications are the instructions to the computer designers and programmers. They also form the body of the contract between the user and the supplier. They must be detailed and complete.

One of Napoleon's maxims is "if an order *can* be misunderstood it *will* be misunderstood."

This rule applies with equal force to computer specifications.

The specifications must contain the process operation description. The programmer cannot be expected to develop the description of the operation of the mill. His job is to translate that description into computer language.

It is easy to see that the preparation of a document such as this can be a difficult chore. It can be done only by dividing the computer system into as many separate functional subsections as possible. Each function then can be described as if it were an independent system.

As an example, the organization for a continuous hot strip mill computer system specification could be:

1. Mill description and data.
2. System objective and general operation.
3. Slab and order tracking function.
4. Roughing train control function.
5. Finishing mill control function.
6. Runout table and coiler control function.
7. Production logging function.
8. System protection function.
9. List of hardware.

The description of the mill or process should include a sketch showing location and physical relationship of one part to another, and a flow diagram of the process

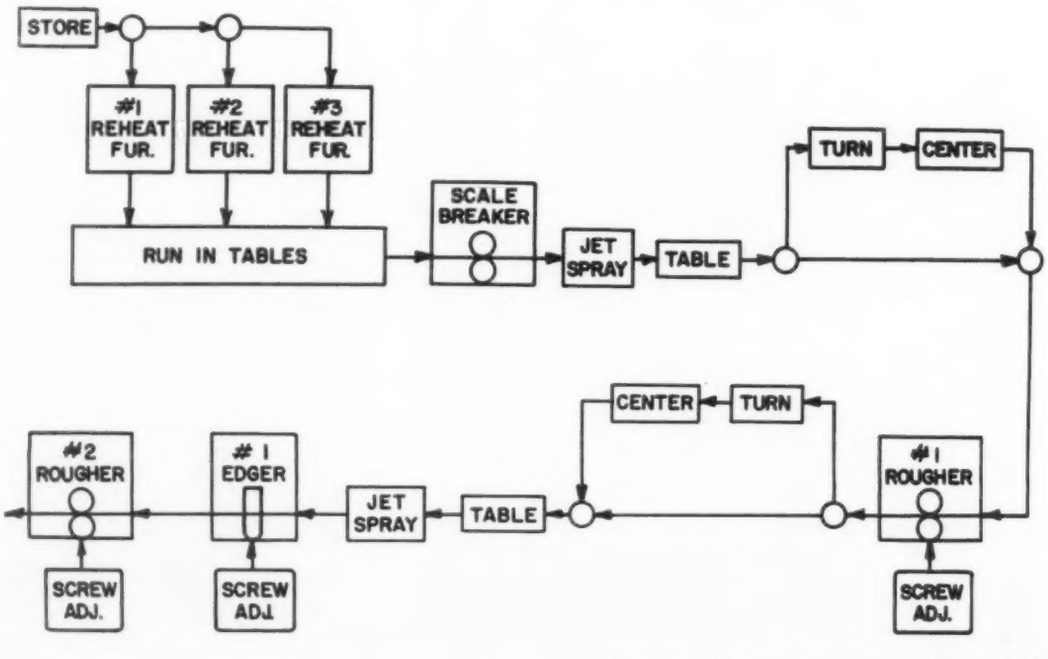


Figure 10 — Flow diagram for hot mill process.

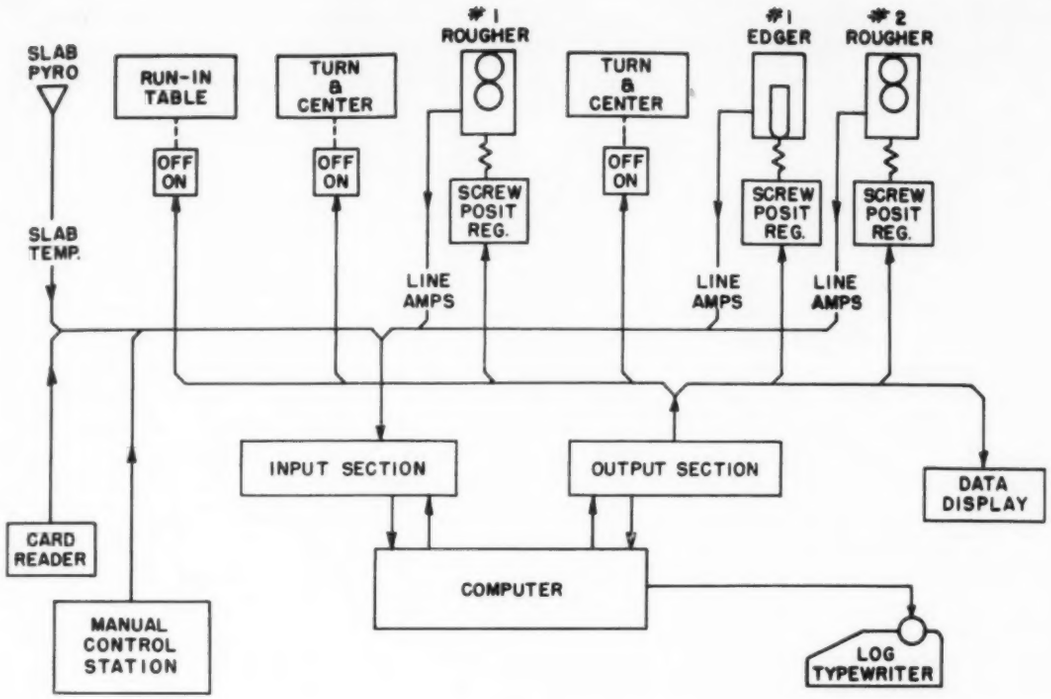


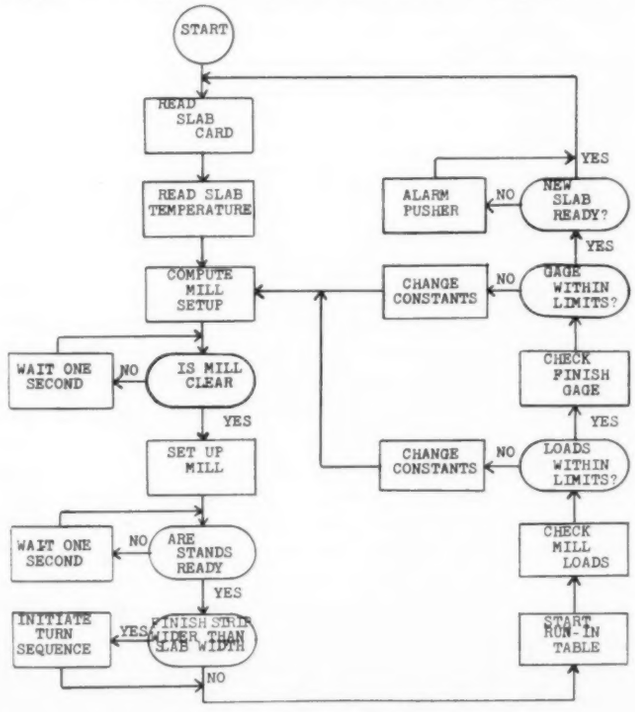
Figure 11 — Block diagram gives interconnections for computer setup on hot strip mill.

operation. Examples are shown on Figures 9 and 10.

The specifications for each of the individual functions should include:

1. Block diagram of the function showing all related hardware and interconnections (Figure 11).
2. Description of the computer function through each cycle including the tables, and values utilized to perform the operation.
3. Typewriter log or card punch formats and arrangements.
4. List of data inputs, data generated, and data outputs.

Figure 12 — Typical computer function flow diagram.



5. Sensor and actuator device characteristics and calibration data.

The organization and arrangement of the specifications are up to the ingenuity of the individual, and one man's system will seldom appeal to another. The writer's experience has indicated that redundancy is useful in the initial stages of a project. It helps uncover typographical errors and foggy statements. The final draft, however, should eliminate all repetition so that each item appears at only one place in the specifications. If time permits flow charts of each function should be prepared. These are graphical representations of the operational logic required to accomplish the particular function. No clearer method exists for describing an action. An example is shown on Figure 12.

The writer has also found that a tabular work sheet such as illustrated in Figure 13 is invaluable during the preparation of design specifications.

MATHEMATICAL MODEL OF THE PROCESS

Considerable research and study may be required to develop the mathematical theory of the process to be controlled by the computer. This, in the writer's opinion, should never be conducted as a part of the computer design project itself.

Work of this sort is basic research; it can seldom be fitted into a production schedule.

If it has not been completed before the computer project is initiated, it is possible to design the computer system so that it can be used to collect the data required by the process research project. The computer's initial program can be developed to duplicate the operating actions and logic of the human operators. Upon development of the process mathematics, the computer then can be reprogrammed. This is not as nebulous a concept as it may appear, since there is a limited number of input signals and output actions required to read and control any process in the steel

CODE	DATA POINT								FUNCTION						FREQUENCY		
	DESCRIPTION	UNITS	RANGE	DIGITS	SOURCE	TYPE	LOCATION	DEVELOPMENT	LIMITS HIGH	LIMITS LOW	LOG	ACCT. CARD	CALC.	CONTROL	EA. 15 MIN	EA. SLAB	ON DEMAND
	ANALOG INPUTS									-							
EA1	FURNACE TEMPERATURE	°F	0000 to 1200	4	L.&N. Cat #8728K260 Thermocouple	I.C.	Entry Wall	See L&N Iron Constantin Calibration Chart	1800	-	X		X	X	X	X	
EA2	WATER TEMPERATURE	°F	000 to 212	3	L.&N. Cat #8422K450 Thermocouple	I.C.	Incoming Supply Pipe	ditto above	180		X				X		
EA3	WATER FLOW RATE	GPM	0000 to 9999	4	G.F.E. Model EC-101-138 Transducer	Diff. Press.	Incoming Supply Pipe	25 Volts dc = 10,000 GPM Linear	-	100	X	X			X		
EA4	WATER PRESSURE	PSI	00 to 76	2	G.F.E. Model 776D Transducer	Bourd. Tube	Incoming Supply Pipe	25 Volts = 100 psi Linear	-	25	X				X		
EA5	LINE SPEED	FPM	000 to 750	3	G.E. BC42 Tachometer Generator	D.C. Gen.	Delivery Pinch Roll	125 Volts = 1000 fpm Linear	800	-	X		X	X	X	X	
	DIGITAL INPUTS																
ED1	CREW NUMBER	Code	0 to 3	1	Operators Station Manual		Entry Station				X	X					X
ED2	ORDER NUMBER	Units	0000 to 9999	4	Slab Card		Entry Station	IBM Type Card Reader			X					X	
ED3	REQUIRED FINISH TEMPERATURE	°F	0000 to 1100	4	Slab Card		Entry Station	IBM Type Card Reader			X		X			X	
ED4	SLAB WEIGHT	Lbs.	00000 to 24000	5	Slab Card		Entry Station	IBM Type Card Reader			X	X	X			X	
ED5	SLAB WIDTH	Ins.	00 to 48	2	Operators Station Manual		Entry Station				X	X	X			X	

Figure 13 — A tabular work sheet such as this is invaluable in computer specifications.

industry. These can be provided at the outset. Subsequent reprogramming need require no additional material.

PROGRAMMING ON-LINE COMPUTERS

The operation of a digital computer is set by the instructions stored in its memory system.

A typical computer does only one simple act at a time. At any given instant the computer will be completely absorbed in carrying out one simple command such as striking one typewriter key or adding one number to another. The complete list of all of these simple instructions required for the computer to perform its specified role is its *program*.

In an on-line control computer this program can require from 4000 to 30,000 such instructions.

Now, preparation of a program for an on-line computer that must operate in real time on an industrial process is an art and not a science.

The programmer must not only prepare the program to use as little storage space as possible but he also must arrange the program so that the computer's actions occur at the required time and speed.

Considerable skill and experience is required if the optimum program is to be prepared. A skilled programmer can often rewrite a program prepared by a neophyte in the art, and cut the time and memory space required in half.

The preparation of an efficient program requires time. It is probably safe to say that regardless of the time allowed for its preparation, no program has ever been, or will be, prepared without errors. The correction of the program or "debugging" as it is called in the trade, may require as much time as the preparation of the initial program.

Professor Suskind of MIT once estimated that the average rate of program preparation is one instruction per day including debugging time. Present experience however indicates that this is far too low and that actually anywhere from 8 to 20 instructions per day can be prepared.

Even at this rate it is clear that a complex program involving 15,000 or so instructions can require two or three man-years of programming time.

Large scientific computers are now being used to prepare optimum programs and conversions to computer language. These programming aids as they are improved and developed, will greatly reduce the time and skill required for preparation of specific programs.

Then, too, as experience is gained an ever increasing library of program portions or sub-routines will be available to further reduce programming labor.

Who should prepare the program?—Without an operatable program a computer is useless. Who should prepare this program; the user or the computer manufacturer?

Computer programming, as we have seen, is a specialized business. It can be performed only by professionals familiar with both the general art of programming and the organization of the specific computer they intend to use. Programming industrial computers is far more difficult than programming the standard lines of business computers.

Any skilled programmer can learn to program an industrial computer. The retention of that skill, how-

ever, will require frequent practice. On-line computers, once debugged and placed in operation, will seldom require extensive reprogramming. For this reason alone the writer believes that the preparation of the initial program for any industrial computer will be done by the manufacturer's programmers. These people continually practicing and improving their skill, and having ready access to automatic programming aids, will be better prepared to do this work.

This does not mean that the user should not develop trained programmers of his own. It is certain that from time to time as process knowledge is gained that program modifications will be desired. The manufacturer's programmers may not always be available when needed. To achieve any degree of independence the user should have at least one programmer available in his own organization prepared to perform the program modifications. This individual will retain his skill by maintaining close contact with the manufacturer's programmers so that he can keep up to date on developments in programming aids and the growing library of programs.

RELIABILITY

There are two things required of a digital control computer system:

1. It must do the specified job.
2. It must be reliable.

Reliability in a digital control computer system is obtained by computer design, system design, programming and maintenance.

The industrial computers now available, without exception, are built around the latest solid state devices, mercury wetted relays, printed circuits and the like. All other things being equal, the computer design having the least number of components will be the most reliable.

Thus reliability of the basic computer is determined by the computer design, and the selection and rating of its components. Once a particular model has been selected, the user or systems engineer can affect its reliability only by carefully designing and supervising the installation and connections, so that it is protected from an unhealthy ambient.

The basic computer itself is only a portion of the system, and the system is no more reliable than its weakest element. System reliability, therefore, can be achieved by selecting only the highest quality sensing devices; typewriters, punches and other peripheral systems equipment. Again, reliability is directly related to simplicity. The peripheral equipment should be kept to an absolute minimum. Every input signal, and output action should be forced to justify its existence. It is better to provide space in the original design for later additions, than to load up the system with functions and equipment of marginal utility.

Programmed reliability—Maximum availability will be achieved when failures in any component are detected and identified before they occur. Failing that, it is important that any failure be located in the least possible time. Maintenance records on conventional control equipment and business computers alike have shown that two to ten times as much time is spent locating a fault as is spent in actually repairing that fault.

The program of the computer can be utilized to improve overall process reliability. This can be done by providing diagnostic and system testing subprograms to the main operating program. The diagnostic program would act continually to check the operation of the computer during normal operation. Failures within the computer then would be detected in time to prevent improper actions, with possible damage to the process machinery.

This diagnostic routine should include, wherever possible, reasonability checks of all input signals to the computer. These checks would require the computer to compare each scanned signal value against either a known permissible rate of change or the prior history of that signal. Any scanned value that appeared out of bounds, or unreasonable, would be rejected as unusable and identified to the line operators. With this subprogram, sensing device failures could be detected and located.

System reliability can be further improved by using the computer to scan potential danger spots on the process, such as bearing temperatures, gas analyses, etc., and providing early warning of potentially dangerous conditions.

There has been considerable use of reliability expressions such as "99 per cent availability" and the like. In practice, availability figures of 99.75 per cent have been reported for a six-months period, 24 hr a day, 7 days a week. These figures are impressive and comforting. It is suggested that a figure approaching 100 per cent for every 20-turn period could be achieved through the development of preventive maintenance procedures designed to detect potential failures in the computer and the peripheral system components before they occur.

MAINTENANCE

Although great efforts are being made to build "maintenance free" and "self checking" computer systems we do not have them yet and probably never will. Computer systems will require technically skilled maintenance, the lack of it can make any installation nothing but a costly experiment.

Historically, electrical equipment maintenance has been supplied by the industrial user with backup assistance from the manufacturer. Continuous association with conventional electrical equipment has enabled the user's personnel to acquire and retain adequate maintenance skill. New equipment introduced from time to time has not been drastically different from existing equipment. A high density of such equipment has permitted a reasonably efficient and economic use of the user's maintenance personnel and instruments.

Industrial computers *are* drastically different from most existing electrical apparatus. The normal industrial labor market is practically devoid of computer maintenance skill or experience.

The industrial user has three choices:

1. Train selected maintenance men in his own organization.
2. Purchase maintenance service from the manufacturer to cover this.

3. Ignore the problem.

Traditionally the steel industry has geared itself to perform all of its first line maintenance. The manufacturer is referred to only for maintenance and repair work too extensive for the user's facilities, or that which would tie up too great a portion of the user's own maintenance organization. The writer believes that in the long run this procedure also will apply to computer systems.

Therefore some consideration must be given during the planning of a computer system, to the training of maintenance personnel, the selection of necessary spare parts and maintenance instruments, and the preparation of a maintenance program. The manufacturer of the computer equipment must be relied on for guidance in these matters. While no hard and fast rule can be written, it is anticipated that the maintenance men selected for computer training should have at least two years of technical electronics training from either a trade school, military service school or equivalent, and at least two years practical experience in the actual maintenance of electronic systems. In addition, obviously, the people selected for such training must have a definite aptitude for logical analysis.

The selected personnel will require a minimum of eight weeks of formal training in the manufacturer's plant on the particular computer system being supplied. This training will include some instruction in programming and study of the particular program being prepared for the installation. Efficient trouble shooting later requires this understanding.

Even though a user plans to train his own people for first line maintenance, the ability of the computer manufacturer to furnish resident service on contract should not be overlooked. It will pay a user to carefully examine the service contract terms offered by the various computer vendors. If a large number of units are installed in one plant, this service may prove to be cheaper than "do it yourself" maintenance.

THE FUTURE

Few developments in the past ten years have excited as much interest and engineering effort as the industrial control computer.

Improvements in computer components and designs are sure to come. The operational limitations described in this paper will probably disappear. Computers of the future will have improved operating abilities.

As these systems become more commonplace their design and application will become easier.

The continued successful use of these new machines will certainly require the development of new and improved sensing devices. We shall see the mechanical design of many processes altered to better match the requirements of computer control.

New developments in this area are proceeding faster than installations can be installed, operated and analyzed. As a consequence there are undoubtedly many mistakes being made and repeated.

The Association of Iron and Steel Engineers offers a medium through which experiences with these computer systems can be shared. It is hoped that the coming years will see many other papers devoted to the problems encountered, the solutions developed, and the results obtained with the systems that are now being installed.

Discussion

PRESENTED BY

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DANIEL D. SHEARER, Jr., Industrial Economist, Division of Economics Research, Stanford Research Institute, Menlo Park, Calif.

R. W. KIRKLAND, Steel Mill Application Engineer, Metal Rolling & Processing Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

A. W. Smith: The steel industry has ordered digital control computers for a variety of applications. Our company is now designing and building three computers for reversing primary mills. This is a natural extension of our activity in the card programmed mill control field. Two of these computers are for reversing plate mills.

There are many areas in the steel mill that would be suitable for a computer from the blast furnace all the way through to the tinning line, but the plate mill seems particularly suitable. The need for better controls on a plate mill is indicated by the "Standard Manufacturing Tolerance For Carbon Steel Plates." For example, the total weight of a group of plates that are ordered to be ½-in. thick and 120 in. wide can be as much as 10 per cent heavy but any individual plate cannot be more than 0.01 in. under the specified thickness. This allowable overweight covers a range from 3.5 to 21 per cent for plates up to 2 in. thick, the higher figures being for the thin, wide products.

These tolerance figures are not surprising when you consider the roll bending and the housing deformation on a wide plate mill. The roll bending not only makes it difficult to set the screwdowns to produce a desired output thickness, but it also makes it difficult to produce flat plate. For a given amount of roll crown, the right amount of roll force to produce flat plate depends on the alloy, the plate temperature, width, and draft. The drafting procedure which depends on so many variables is a very suitable job for the digital control computer.

The application of a control computer to a reversing plate mill requires a good understanding of the whole process. A team of experts are investigating all aspects but particularly the characteristics of the stand and the metals to be rolled, so that the drafting, gage control and shape control problems can be solved. When the mill is first installed, a data logging system will be used to confirm the preliminary studies.

The digital control computer will surely improve the operation of the reversing plate mills, but time will be required to show all the far reaching advantages.

Daniel D. Shearer, Jr.: Mr. Kirkland has presented a very realistic picture of digital control computers as they will be applied to steel processes. One could wish that

more of the first ten installations would live up to their name of control computers. However, we are sure that the process information gained where they are applied as data loggers will lead to control in the not too distant future.

From the authors paper it is evident that his company believes the digital control computer is a very versatile instrument. He mentions data logging and alarming functions, as well as control. In the control area he mentions that the computer should not be used to directly regulate a control variable but should be used to set an operating point for an analog type controller. If this is true, why did his company select a digital control computer for controlling applications instead of a card reader or less expensive analog computer to set the operating points?

Programming is a subject that has not received enough attention by those purchasing control computers. The author's comment that a purchaser of a digital control computer should make arrangements to train a member of his staff in programming is very significant. Business computer users have found this to be a very necessary move that gives them much more satisfaction from their equipment. The reason for this is simple. Reprogramming following installation has occurred more often than not. Generally such reprogramming has taken place for one of three reasons: (1) because the original program and/or process had to be debugged; (2) modifications to the system or process were needed, or (3) improved program knowledge became available.

While on the subject of programming, it might be mentioned that one of the arguments advanced for the use of digital control computers is that the program can easily be changed in minutes if it is desired to utilize the equipment on a new process. This is true if a program that fits the process is available. If not, it may take 14 man-years for a 30,000 instruction program to be prepared, as discussed by Mr. Kirkland.

Perhaps 20 years in the future programming problems will not be important, as the adaptive or thinking computer of tomorrow becomes available. However, the availability of a good program library from a manufacturer today should be an important point in computer selection.

Mr. Kirkland lists the number one process characteristic desirable for computer control as "a process with a continuous high production rate." We expect the first completely successful control computer application in the steel industry to be on a batch process—a hot reversing mill. Generally, the utility and petroleum industries have found that computers have excellent potential when complex startup and shutdown operations occur frequently. On such processes a computer can be used to obtain faster cycling times with much less chance for error.

One process characteristic not listed by Mr. Kirkland but at least as important as the others on his list can be stated as follows:

"The ability to measure continuously the important process variables."

This can be accomplished either directly or by computer synthesis for measurable variables. Would the author comment on the availability of adequate sensors for the various steel processes?

R. W. Kirkland: We said that a process should have a high production rate and that it should be continuous or highly repetitive if it is to be considered for computer control. This will include the batch operation reversing mills. We do not know the installation schedules of all of the computer systems that are now going in but suspect that the first successful control computer in the steel industry is now being manufactured or installed and that the honor of being first is going to depend more on installation scheduling than on the particular process involved.

We listed that particular process characteristic first for its economic rather than technical effect. A process simply has to have a high tonnage rate in processing steel to justify the cost of a computer control. Steel as a product is important because it is relatively inexpensive. That characteristic could be omitted if we were considering a batch type process for manufacturing diamonds.

Digital control computers will supplement card programming systems and analog regulators rather than compete with them. Card programming systems are fine for mills that require only 50 or so different rolling schedules. If a large or unpredictable variety of rolling schedules are expected, then a computer system is the only alternate to manual control.

Digital computers should not be used to directly regulate a process variable when that process variable may be more cheaply regulated by existing, proven, analog regulator devices. Again it is a question of economics.

It would be poor engineering indeed to use a $200,000 computer to perform a chore that could be handled just as efficiently by a $2000 recorder controller.

Mr. Shearer is right in stating that the successful application of computer controllers requires the ability to measure continuously the important process variables.

This may well be the first commandment. So far however it has not limited us and we do not think it will. Many reliable, proved sensing devices are now available because the manual operation of processes has required them. New sensors are now being developed and others will be produced whenever the need arises.

These sensors, again, should be considered from a systems point of view. In the past, developments in this field have lagged occasionally because users objected to the cost. Considered alone, outside of a system, a given sensing device may be very expensive since it perhaps has a limited market and two or three units have to bear all of the development costs. As a vital part of a control system that same device may be cheap at twice the cost.

It is perhaps proper here to add a comment of our own and that is that the human operator is still the world's most versatile sensing device. No instrument will ever be developed that can match the human eye coupled to the discriminating powers of the human brain. Skilled operators will always be needed. The human factor must therefore be included in the planning of a control computer system. This may even require revision of a users incentive system if that is needed to inspire the operators to help rather than hinder the automatic control. ▲

Filtration In The Iron and Steel Industry

by JOHN R. McCOY, Manager of Technical Services, Indiana Commercial Filter Corp., Lebanon, Ind.

. . . . filtration of fluids and air used in steel mill applications is a standard maintenance procedure which cuts downtime delays . . . in filtering particles, size and removal is influenced by types of fluids, flow rates, pressure drop, viscosity, type of circulation and type of particles . . . .

MACHINES used in the production of steel are gigantic in size. Speeds and pressures are often quite high. Adverse conditions prevail, such as shock loading, exposure to water, mill scale, normal mill dirt and high heat. Machines must operate with high precision. Adequate lubrication is a "must." Lubricants cannot do their best job of lubrication if contaminated with oil oxidation products, water, mill scale and general plant dirt. Adequate filtration or clarification is required in order to obtain adequate lubrication.

It is not within the scope of this paper to discuss all of the various types of applications in a steel mill where filtration may be applied. Methods and practices vary considerably from plant to plant. A study of basic filtration fundamentals will give a better understanding of filtration in general and will point the way to the proper selection of filters for any specific application.

BASIC FILTRATION FUNDAMENTALS

The iron and steel industry uses many kinds of lubricants in many types of applications. Many of the lubrication processes are carried out with greases and oils of a consistency that cannot be filtered. Some of the oils are quite heavy and require only a rough straining operation. Other processes use light viscosity, high grade oil and require the very highest degree of filtration.

Filtration, as a rule, involves many compromises. These compromises are very pronounced in many phases of the iron and steel industry. Flow rate, particle size removal, per cent removal per pass, pressure drop through the filter, high contaminant removal and size of the filter are all related. Very few, if any, filters are absolute. They will all allow a percentage of contaminant to pass. In order to improve particle size removal and a higher percentage of contaminant removal per pass, the filter cartridge must be made denser, thus increasing pressure drop or decreasing flow rate. To obtain higher flow rates without increasing the pressure drop across the filter, the density of the cartridge must be made less or the size of the filter made larger. If the size of the filter is held constant, then the density must be made less, and thus allow larger particles and a higher percentage of the dirt to pass through. It is always desirable to have a low pressure drop, high flow rate, good particle size retention, high percentage of contaminant removal per pass and a small filter with high dirt holding capacity, all built into one unit. It can be seen from the above discussion that it is impossible to have all of the desirable features and none of the undesirable features built into one unit—thus it is necessary to compromise.

Flow rate and pressure drop are directly proportional to the operating viscosity. The higher the operating viscosity, the higher the pressure drop across the filter for a given flow rate. Operating viscosity is the viscosity of the oil at operating temperatures. High viscosity oils are more difficult to filter than low viscosity oils because they tend to hold onto the contaminant more tenaciously than low viscosity oils.

Oil or water can be filtered relatively easily without the presence of the other, but a mixture of oil and water renders the filtration process quite difficult. A relatively dense filter which will give fairly efficient filtration on either water or oil will block off, sometimes completely, when filtering a mixture of the two. A small percentage of water in oil or a small percentage of oil in water will stop the flow. A wide open strainer is

usually necessary to strain out (not filter) contaminant where a mixture of oil and water is present. Water is used in steel mills literally by millions of gallons per day. Some of this water finds its way into the lubrication system of the mills and thus causes the problem of having to filter a mixture of oil and water.

There are several ways of applying filters in actual practices. These methods may be classified as: (1) full flow, (2) by-pass, (3) shunt and (4) circulation by means of an auxiliary pump and motor. Many lubrication systems utilize a pump to supply lubricant to the lubricated part. In some cases the lubricant, whether oil or grease, is a "one-shot" proposition and any extra lubricant will be wasted. Some systems flow oil to the lubricated part and back to an oil reservoir where it is filtered and used again—thus we have a "circulating" oil system. The circulating oil system is the type with which we are principally concerned in this paper.

A full flow filter will actually filter 100 per cent of the oil passing to the lubricated part each time the oil passes to that part. A by-pass or bleeder system will bleed off a small percentage of the oil from the pressure line of the lubrication system, pass it through the filter and discharge it back into the reservoir. A shunt type arrangement allows part of the oil to pass through the filter and then discharge back into the main oil stream so that all of the filtered oil passes directly to the lubricated part. In this case, a means of controlling the pressure, such as a pressure control valve, must be placed in the main lubricating oil line so as to cause a portion of the oil to pass through the filter. The fourth method involves a separate pump and motor to pick up the oil from the oil reservoir, pump it through the filter and discharge it back into the oil reservoir. By this manner of operation the filter may operate entirely independent from the rest of the system. The filter may be run when the rest of the system is not even operating if desired. The filter can be shut off for changing refills, or merely to stand idle if desired. All four methods of operation may be used at some place or other around a steel mill.

Filtration may be done on a continuous basis or intermittently. Continuous filtration is the most efficient and economical way to operate a filter. It is preferred over intermittent filtration or batch filtration because the contaminants can be removed as they enter the oil. This method allows the machine to operate on clean oil at all times. Intermittent filtration or batch filtration allows clean oil operation only for a short time after the filtration or reclamation operation; but unless continuous filtration is employed, the machine will be operating on partially dirty oil a major portion of the time. Any machine which operates without the benefit of continuous filtration is continually subject to abrasive wear even though the oil is changed at frequent intervals. Frequent oil changes without filters will greatly reduce wear but changing of oil cannot be substituted for continuous filtration. The major purpose of oil filtration is to prevent wear and downtime of the machine. Oil savings are secondary, although they are no small item. Cost of oil is minor when compared to the cost of repairing a large mill or the loss in production due to downtime. Lubricating oil cannot do its best job of lubrication if dirty. It is the function of continuous filtration to maintain the oil

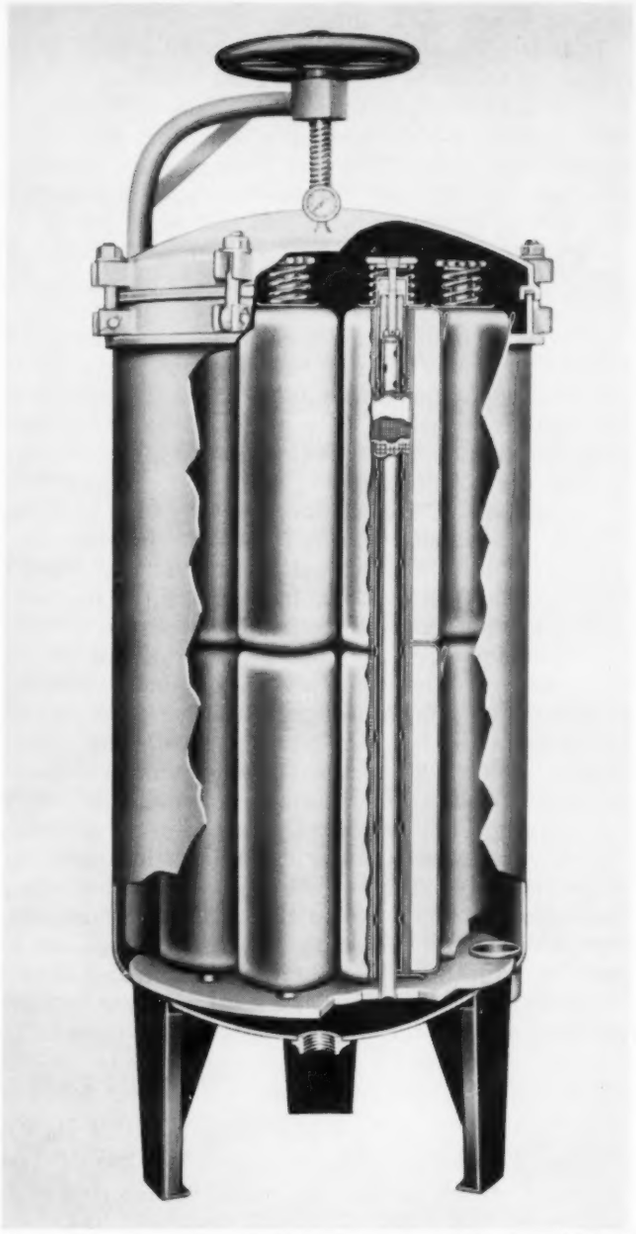
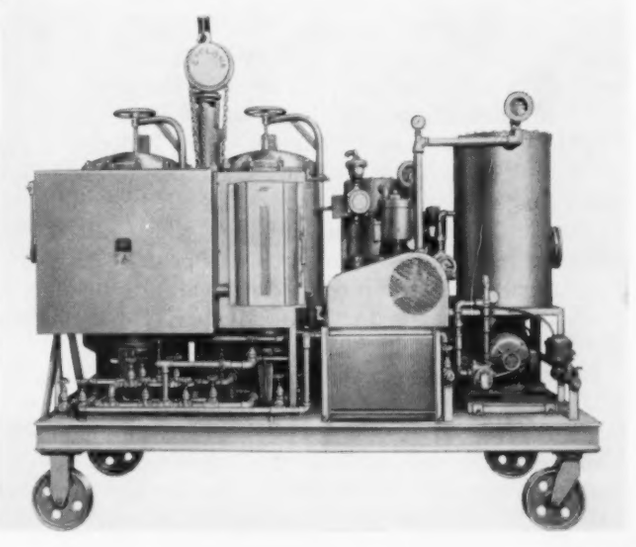


Figure 1 — Fullers earth filters can remove both solid and soluble contaminants.

Figure 2 — Filters are commonly used for insulating oils.



as clean as possible at all times.

It is much easier, and a much smaller filter is required, to maintain an oil in a good condition by continuous filtration than to reclaim it once it has become unfit for service. Deterioration products act as catalysts to accelerate the formation of more such deterioration products. With proper filtration the rate of deterioration can be greatly reduced and the useful life of the oil greatly prolonged. Filters should be installed to operate on new oils and then the oil will be maintained in good condition so that it can perform its given function best. It is not impossible, but sometimes rather difficult to restore a badly contaminated oil to an acceptable condition with filters that are designed to maintain in-service oil in good condition. Many refill changes may be necessary before the oil is restored to a satisfactory condition.

Particle size ratings of filter cartridges are receiving entirely too much attention at the present time. There are no standard methods of running particle size removal tests among industrial filter manufacturers and no standard methods of reporting ratings. One manufacturer may rate his cartridge at 98 per cent removal of the stated particle size under operating conditions on a one pass basis. Another may rate his cartridges at 85 per cent removal when using refined fuel oil and after recirculation, a completely different set of circumstances. Particle size removal is influenced by types of fluid, flow rates, pressure drop, operating viscosity, whether one pass or recirculation, and type of particle involved. Particle-size-removal determinations are quite difficult to run and get reproducible results even with the same operator. Ratings can be relative only in one manufacturer's products and cannot be compared with any degree of accuracy between different manufacturers.

TYPES OF FILTERS

Filters can be divided into many types or classifications. These classifications may include depth type, extended area or surface type, edge type, screen type, bulk type, bag type, adsorbent, absorbent, etc. Centrifuge and magnetic separators deserve mention, however, they are not true filters. Filters are usually designed for one or more specific purposes, but none of them can be applied equally well to all applications.

Depth type filters require the oil to flow through a depth of the filter medium. The depth of the filter medium may range all the way from approximately one up to approximately 15 in. The sediment is distributed throughout the depth of the filter medium. Depth type filters can be made of many different types of filter media, such as fuller's earth, cotton, wool, plant fibers or mixtures of these. Depth type cellulose filters can be made from bulk materials, batted and garneted materials or from rovings. Specially processed rovings can be wound into a cylindrical form into many densities to give the dirt holding capacity and particle size removal desired.

Surface type filters remove their dirt actually on the surface of the filter. Surface type filters depend on a large surface area for their dirt holding capacity. The larger the surface area, the larger will be the dirt holding capacity. These filters are usually made of paper or cloth. The filter medium is arranged in such a manner to provide a large surface area in a relatively small space. The paper may be folded into an accordion pleat and wrapped around a centertube. Considerable space can also be obtained by cutting disks in various shapes from paper or chip board and stacking them on top of each other with separating disks of some sort in between.

Bulk type filter housings usually come equipped with baskets and centertubes. Bags for holding the filter medium, accessories, such as centertube wrappings, gaskets, etc., and the filter medium either adsorbent or absorbent are expendable and may be purchased from the filter manufacturer. The operator fabricates his own refills. Bulk type filters are available either in single cartridge models or in multicartridge models. Maximum flow rate through a single bulk refill element is somewhere in the neighborhood of 10 gpm, but in most cases the flow rate will be somewhere in the neighborhood of $3\frac{1}{2}$ to 5 gpm, depending upon the operating viscosity of the oil. Single element bulk filters may contain as much as 450 lb of fuller's earth. Multi-element bulk filters may contain as much as 700 lb of fuller's earth in one filter housing. Because of the weights and sizes of the larger bulk type refills, hoists are required to handle the spent refills. A fuller's earth refill will pick up its own weight of oil by adsorption, plus the amount of dirt which it filters out. A single spent element may weigh as much as 1200 lb.

Inert type filters are designed solely for the purpose of removing solid contaminants. Most absorbent type filters have a small capacity for removing acids, etc., but this capacity is quite small when compared to the adsorbent capacity of fuller's earth.

Fuller's earth filters are capable of removing both solid and soluble contaminants. Soluble contaminants may include acids, asphaltenes, color bodies, etc. Fuller's earth filters are designed primarily for adsorbing soluble contaminants. Cellulose cartridges are designed for removal of solid contaminants. The dirt holding capacity of a cellulose type filter is usually much higher than for a fuller's earth filter.

Because of its adsorbent nature, fuller's earth will remove by adsorptive action any polar molecule which may be in the oil. This molecule may be acid, asphaltenes, rust inhibitors, detergents, etc. Where oils containing additives of a polar nature, such as rust inhibitors or detergents, are concerned, fuller's earth is not usually indicated except in specific cases. Fuller's earth is not indicated where water is a contaminant. Fuller's earth will lose its granular form in the presence of water and form a mud. When this happens flow rate through the filter will be stopped and it will be necessary to change the filter cartridge. Fuller's earth actually can be used to remove very small amounts of water from an oil, but where the total volume is very high the use of fuller's earth for water removal would be uneconomical. Where large sediment loads are encountered, cellulose type filters are indicated.

ROLL MILLS

The lubrication of the gears and bearings of a steel roll mill may include various types of lubricants, such as greases, very heavy oils, etc., and these lubricants may be applied by various lubricating devices, such as pressure systems, drip systems, hand packing, mist

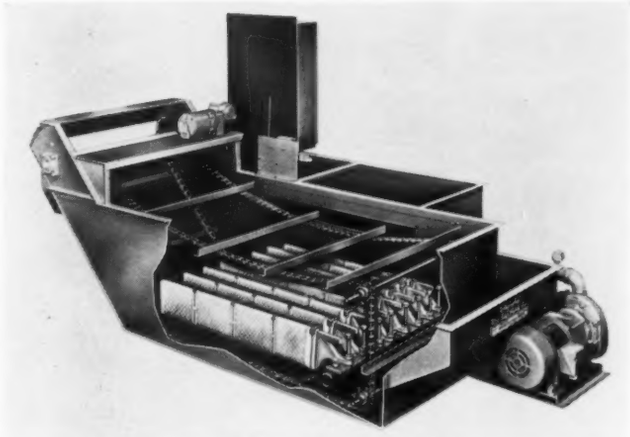


Figure 3 — This unit is used for filtering metal working coolants.

lubrication, circulating oil systems, etc. Greases and some very heavy oils are not filterable, and consequently, will not be considered here.

Roll mills work under very adverse conditions. During hot rolling operations, heat from the slab or bloom is transferred to the rolls and the bearings. Water is sprayed on the rolls to cool them. High pressure water is sprayed on the metal being rolled to remove mill scale. In spite of all precautions this water and scale gradually will enter the lubricating oil, and unless removed will render the lubricating oil unfit for service in a short time. The oil used is usually quite heavy, ranging up to 4000 SUS at 100 F. Water, scale, rust, plain mill dirt and oil oxidation products combine with the oil to form a sludge which may or may not settle. Water will emulsify into the oil and form water-in-oil emulsions, and if allowed to accumulate over a long period of time may actually form into a mayonnaise like consistency. Lubrication and cooling of the bearings will be greatly reduced. The combination of a heavy oil, water, scale, rust and dirt all add up to a difficult lubrication and oil clarification problem.

Slow speed mills can tolerate rather high percentages of water (5 to 25 per cent) for short periods of time. It is desirable to keep the water content very low (less than 0.5 per cent) in mills operating at high speed. Oil temperature of high speed mills rise as the water content increases.

Large lubrication systems are usually used with roll mills. Where water is involved, two large settling tanks, ranging up to 10,000 gal each are provided as reservoirs. These tanks should be properly heated and equipped with baffles to facilitate settling of water and scale. Plain unbaffled tanks will allow circulating oil to channel right through the tank and allow relatively little retention time. In plain tanks, only a small amount of the oil may actually be in use and circulating. The rest of the oil may remain stagnant and not move. In such systems, very little settling of water and dirt will occur. In properly designed tanks all of the oil will move slowly and separation and settling of some of the water and solids will result. As the oil is used, water will gradually accumulate and after a week or two the water content of the oil may become so great that the oil is no longer fit for service. The standby tank is then brought into use. Oil in the resting tank may be heated to 180 to 200 F. This thins the oil, breaks simple emulsions and allows the water to settle so it can be drained off. Centrifuges may be used to aid in water removal. Water analysis should be made every day and the tanks alternated as needed; probably once every one or two weeks.

Heat alone is very good in breaking emulsions, but often, stubborn emulsions form and emulsion breakers are necessary. These emulsion breakers are added in the amount of approximately 0.1 per cent by volume. They must be thoroughly mixed with the oil being treated. In combination with heat they are very effective in breaking emulsions and allowing the water to separate and settle. Emulsion breakers are also quite effective in preventing emulsions from forming in the "in-process" oil.

Additional water removing or separating aids are recommended, such as centrifuges, separating screens and filters. As has already been pointed out, these filters operate best when used continuously. It is the practice in some plants to use centrifuges only after the water content of the oil has built up to a rather high level; sometimes, only when the oil is on standby and settling.

Filters used on the lubricating oils of roll mills are usually of the metal screen, metal edge magnetic bag type or centrifuges. Highly efficient filters, such as are used on hydraulic oils normally are not used because of the difficulties in filtering high viscosity oils and mixtures of oil and water.

As the oil is used in the lubricating system, it will gradually deteriorate and form products of oxidation, such as acids, asphaltenes, etc. These products of oxidation, as well as finely divided metal and water, act as catalysts to accelerate oil breakdown. They also act as emulsifying agents to emulsify water into the oil and prevent it from separating. Acids may attack bearings and cause pitting. At intervals of six months to a year it is desirable to remove the oil from the system, completely remove all water and filter the oil through fuller's earth type filters. Oil containing water cannot be filtered through fuller's earth. Fuller's earth will remove all oil deterioration products and place the oil in essentially a new condition. Fuller's earth will also remove rust inhibitors, so, if the oil contained rust inhibitors, it will be necessary to reinhibit by the addition of inhibitor concentrate or the addition of new oil containing inhibitor.

In hot rolling operations only water, no oil, is sprayed on the metal being rolled. In cold rolling operations, involving flat stock, such as sheet and strip, some sort of lubricant is sprayed or dripped on both sides of the metal being worked immediately before the metal passes through the rolls. This "roll oil" serves to lubricate the steel as it passes between the rolls to prevent scratching of the metal and to protect the highly polished roll faces. It also aids in obtaining a bright smooth finish. Any imperfection in the roll faces will be imprinted on the metal. Considerable heat is generated during the rolling process, and the lubricant acts as a coolant to carry away the heat. It also acts to carry away small bits of metal which may break away.

Roll oils will vary considerably from plant to plant and operation to operation because of variations in speed, pressure, amount of reductions, type of product

and desired finish of the product. Roll oils may be straight mineral oils, palm oil, synthetic oils, various mixtures of these, mixtures of these oils with additives and/or water or soluble oils. As far as filtration of steel rolling oils is concerned, each application must be considered on its own merits. Generalizations or "rules of thumb" cannot be made because of the variety of oils and methods in use. The addition of water to the roll oil renders filtration practically impossible unless the water is separated first and this involves large settling tanks with heat. Mixtures of palm oil and water form difficult emulsions and when heated turns into a gel-like material. Special processes are required for the reclamation of palm oil.

As the quality of the finished metal improves, the condition of the roll oil must also improve and be free of contaminants. Some cold rolling processes may render the oil so contaminated that anything better than magnetic separation would be uneconomical. Magnetic separators will take out the large particles and some of the fine particles, but they are not highly efficient. The more viscous the oil, the less efficient the magnetic separator becomes. When high quality processes using mineral oils are involved, filtration is highly desirable. For maximum protection, full flow filters are used. These filters should be capable of removing practically everything down to 20 microns on each pass and they should provide high flow rates at low pressure drops. Diatomaceous earth precoat filters may be considered. To maintain the oil in good condition chemically, fuller's earth filters may be used to circulate on the oil reservoirs to remove oil deterioration products such as acids, asphaltenes, etc. Fuller's earth filters will also remove undesirable additives which may leak into the oil with bearing lubricants.

Specialized mills, which use the roll oil as a bearing lubricant, require additional filtration facilities to further filter the portion of oil that passes through the bearings.

HYDRAULIC OILS

Many machines and mechanisms in steel mills and related industries are hydraulically operated. It is important that these hydraulic devices are maintained correctly or considerable downtime will result and much labor will be required to place them back in operation.

Hydraulic machines are precision built of the finest materials and workmanship. These machines will remain precision machines only as long as they are properly cared for. The hot, dirty operating conditions of steel mills render the maintenance of hydraulic machines difficult. Abrasive dirt and water get into the hydraulic oil. The dirt circulates through the precision fitted parts and causes abrasive wear. Leakage through valves, pumps, etc., causes loss of pressure and flow. Small orifices may become plugged. Sediment may cause vanes of pumps to wear or stick. Seals may be cut out by abrasive action. Water mixes with the oil and reduces lubrication. Water accelerates oil deterioration. Rusting of parts may result. As the oil is used it will gradually deteriorate and form acids, asphaltenes, resins, varnishes, etc. Acids will attack metal and cause acid corrosion. Asphaltenes and varnishes may deposit on various parts to cause them

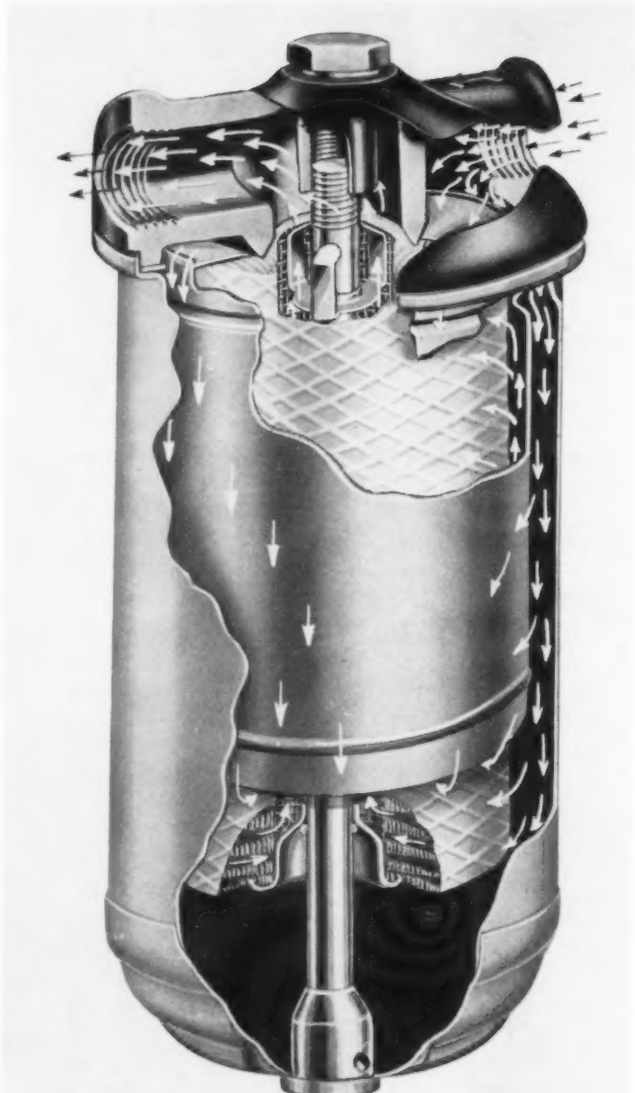


Figure 4 — It is necessary in many cases to filter air in compressed air lines.

to become sluggish or actually stuck, thereby rendering them inoperative. Both the hydraulic machine manufacturers and the oil companies state that dirty hydraulic fluids account for the majority of troubles with hydraulic machines. Manufacturers have made special efforts to design the machines so as to prevent the entrance of dirt and water, but it still gets into the systems. It certainly is good insurance against wear and breakdown to provide adequate hydraulic fluid filtration.

Two types of filters are usually used in hydraulic systems. A strainer is usually mounted in the oil reservoir on the suction piping of the pump. This strainer is usually made of 100 or 200-mesh screen and is specifically designed to afford a large surface area. A 200-mesh screen has openings of 0.0029 in. or approximately 75 microns in size, and a 100-mesh screen has openings of 0.006 in. or 150 microns. This strainer is only a "nut and bolt" catcher and is not meant to do the whole job of filtration. It protects the pump and other parts from serious damage in case some large part may get loose

in the system. The strainer cannot be expected to protect parts that have clearances sometimes as small as 0.0002 in. or 5 microns. The hydraulic system should also be equipped with a second filter, a highly efficient one, for removing the small abrasive particles that circulate through the system with the hydraulic fluid. These filters normally are not supplied as standard equipment with the system and must be purchased as accessory equipment.

This highly efficient filter may be placed many places in the system. It may be a by-pass type filter, bleeding off a small amount of the hydraulic oil from the discharge line of the pump. Some device, such as an orifice, flow or pressure control valve or relief valve, must control the flow and pressure to the filter. Unless specially constructed, most filter housings will not stand the full pressure of the system. The filter may be a full flow type placed directly in the discharge line of the pump. Specially constructed high pressure housings are necessary when placed in this position and the filter elements must allow high flow with a minimum of pressure drop. The filter may be placed in the return line of the system and installed to take either full flow or operate as a by-pass filter.

The best way to install the filter is with a separate pump and motor to circulate on the reservoir. In this position the filter operates completely independent of the hydraulic system. It can run when the system is not operating if desired.

Continuous filtration is always best. Where several relatively clean operating systems are located close to each other, it may be desirable to use a portable filter to service all of the machines. The filter is mounted on a dolly and equipped with pump and motor and hoses so that it can be moved from machine to machine. The oil in each machine should be cleaned once every one or two weeks, depending upon the operating conditions.

When water gets into the oil it may be necessary to remove the oil from the hydraulic system, place it in heated settling tanks and settle out the water. It should be raised to 180–200 F and held for 24 to 48 hr, after which the water can be drained off. It can then be filtered very nicely and placed in an excellent condition.

Fuller's earth is the recommended filter medium when straight mineral oils are used and inert filter medium is recommended with additive type oils. Properly maintained hydraulic oils require few, if any, changes.

Synthetic fluids have made their place because of their nonflammable characteristics. The need for filtration with these fluids is even greater than with mineral oils. Synthetic fluids have very good solvent action and will actually break loose particles, crankcase sealers and paint which will not be affected by mineral oil. Synthetic fluids often contain high percentages of water. Interchangeability of mineral oil filters with synthetic fluids is not always possible. Consultation with the filter supplier is desirable if such a change is contemplated.

INSULATING OILS

Without electric power a steel mill would be helpless. Some of the larger mills generate their own power. Others purchase electricity but own their own power and distribution transformers and circuit breakers.

Transformers and some circuit breakers are oil filled. Oil in the transformers deteriorates much the same as any other mineral oil except at a slower rate. The type of transformer, whether free-breathing, conservator, gas filled, etc., has a big bearing on the rate of deterioration. The principal deterioration products formed are acids, asphaltenes and water. Acids attack the cellulosic insulation and weaken it. Acids also decrease the demulsibility of the oil, thereby causing it to hold on to the water rather than let it drop out. This increase in water content causes a reduction in dielectric strength which could cause arcing and failure. Water may also enter the oil when the transformer breathes. A small amount of asphaltenes will stay dissolved in the oil, but as deterioration proceeds the oil will become saturated and solid asphaltenes will precipitate throughout the core and housing of the transformer and also in the cooler tubes. This coating prevents heat transfer and heating of the transformer results. Conductivity of the wire is reduced by the heat, thus causing greater resistance and more heating. The higher operating temperature accelerates the deterioration rate of the oil (double for each 18 F rise), and thus a vicious cycle develops.

If bad oil is allowed to remain in the transformer long enough, failure may result or sludge may get so bad the core will have to be removed and the sludge scraped out with a putty knife.

Periodic testing of the transformer oil is necessary. These tests should include neutralization number, interfacial tension and dielectric strength. When the neutralization number rises to somewhere in the neighborhood of 0.4 to 0.6, and the interfacial tension value drops to somewhere in the neighborhood of 17 dynes, the oil should be filtered through fuller's earth type filters. After the fuller's earth treatment, the oil should be dehydrated so that the dielectric strength will be restored. Fuller's earth treatment will remove the acids, asphaltenes and dirt which may get into the insulating oil, but it will not restore the dielectric strength. Dehydration must be carried out through one of a number of available dehydrators, such as vacuum dehydrators, blotter presses or centrifuges. Spray type vacuum dehydrators are the best because they will remove both soluble and free water to a very low level. They will also degasify the oil.

A number of transformer oil reclamation units are available. Some contain only dehydration equipment. All reclamation units that will restore the chemical conditions of the oil are equipped with some sort of adsorption filter, but the type of filter that is most commonly used, and most economical, is the fuller's earth filler. Dehydrators and filters may be mounted on the same base into a common system. Special filter systems equipped with spray type vacuum dehydrators are capable of completely restoring the chemical condition of the transformer oil, and also completely dehydrating and degasifying the oil on transformers in service without ever shutting off the power. These units have all automatic controls so as to eliminate the human factor during operation. With other types of units, without automatic controls, the recommended procedure is to shut off the power before starting the reclamation process. In some plants and operations,

it is rather difficult to find a convenient time when the power to the transformers can be shut off. After the oil has been completely reconditioned, it is recommended that a suitable oxidation inhibitor be added to the oil to increase its life expectancy.

Circuit breaker oils do not deteriorate very badly, but the oil becomes filled with carbon from the "making and breaking" of the circuit breaker. This oil can be handled very much the same as the regular transformer oils, with the exception that a much smaller amount of fuller's earth is required for the reclamation process. This oil also must be dehydrated.

MISCELLANEOUS

Many side operations in a steel mill involve filtration. Some of these are mentioned as follows. Some are rather complicated and would require a full technical article to discuss them in full.

Air filter oil—Dirty, unfiltered air used in blast furnaces causes considerable abrasive wear to the blast furnace fans. To prevent this wear the air is frequently filtered. Industrial air filters use oil to wet the air filter elements and also to clean them. Oil filters will maintain the oil free of the sediment removed from the air and reduce considerably the maintenance required to operate filters. Oil consumption also will be reduced.

Steam turbines—Many steel mills generate their own electric power by means of steam turbines. Turbines are high precision pieces of equipment and are lubricated with high grade oil. Highly efficient filters are required to maintain this oil in good condition. Settling tanks, special water stripping filters or centrifuges are also necessary to remove water that leaks past the seals.

Small auxiliary steam turbines operate many devices such as fans, pumps, compressors, etc. These turbines also use high grade oils and require filtration and water removal equipment. Combination filters and water strippers are available to do the job in one operation.

Engines—Miscellaneous internal-combustion-engine-driven equipment, such as trucks, locomotives, air compressors, power generators, etc., use high grade engine oils. The engines operate best and require less maintenance when the oil is properly filtered. Many of the engines come equipped with proper filters, but it is necessary that filter elements be changed when necessary to obtain maximum benefits.

Metal drawing operations—Drawing operations require various types of lubricants. Lubricants containing soap are difficult to filter because the soap is not entirely soluble and tends to slime over the surface of filters and stop the flow. Operations which allow lime to get into the drawing oil also render filtration difficult because of the blinding effect of the lime on the filter. Settling tanks are sometimes resorted to for reclaiming wire drawing oils. Applications should be considered on an individual basis.

Gears—Some gears use high grade oils in light or medium viscosities. It is desirable to filter these oils and this can be done by using an auxiliary pump and motor to circulate the oil through the filter.

Metal cutting and grinding operations—Many operations require metal cutting and grinding machines which use coolants. Clean coolants result in longer tool life, less wheel dressing, better finish, less rejects, higher production and longer coolant life. Many types of filters are used in metal working coolant filtration, such as sock type filters, automatic clarifiers, screen type filters, both suction and pressure, and both automatic and manually operated, conveyorized settling tanks, magnetic separators, etc.

Air filters—Many controls are actuated by compressed air. Unfiltered air allows dirt and water to get into the controls and stop them up, causes them to stick or to rust. Proper filters will remove dirt and water and eliminate problems caused by dirty wet air.

Water—Water is used literally by millions of gallons for a variety of purposes. Some of this water is taken from public water systems and some of it is taken from nearby streams or lakes. The filtration of stream water is very difficult because of periodic contamination of the streams caused by heavy rains. Water treating systems approaching the size of a city water treatment plant or larger are required to adequately handle this water.

SUMMARY

Filtration of the many fluids and air used in steel mills is a highly desirable procedure for maintaining production and related machinery and producing high grade products. Not all of the problems of filtration have been solved. New filtration developments are appearing each day and research is being conducted to solve the problem applications.

Discussion

PRESENTED BY

G. C. ALMASI, Materials and Standards Engineering, Midland Works, Crucible Steel Co. of America, Midland, Pa.

JOHN R. McCOY, Manager of Technical Services, Indiana Commercial Filter Corp., Lebanon, Ind.

G. C Almasi: We are experiencing difficulty with our filtration due to the removing of additives which have been incorporated in highly inhibited oil for specific purposes.

John R. McCoy: In general, high grade lubricating oils are used where the best in lubrication is required. These oils may be additive type oils or straight mineral oils, depending on the application. Where these high grade oils are used, the dirt loads are relatively light. Examples are turbines and hydraulic oils. Highly efficient inert type filters are recommended for additive oils and fuller's earth filters for nonadditive types.

Where turbines are concerned a filtration system is usually required. This system is usually composed of the necessary pumps and motors, together with special water coalescing and stripping tanks and highly efficient filters. These tanks may be equipped with automatic water drains. Modern turbines are usually lubricated with high grade oils containing rust and oxidation inhibitors. Inert filter cartridges are recommended because fuller's earth will remove the rust inhibitor. Intermittent use of fuller's earth may be indicated if the oils show a high amount of oil oxidation products. After using fuller's earth it probably will be necessary to reinhibit the oil with rust inhibitor. ▲

Filtering Air for Steel Mills

by C. D. WRIGHT, Steel Mill Application Specialist
Air Filter Div., American Air Filter Co., Inc., Louisville, Ky.

The actual choice of the type of filter for a specific air cleaning application requires a careful analysis of all the factors involved . . . . the following summarizes important points which must be so considered.

ON many previous occasions the AISE has heard discussions dealing with the need for clean air in certain mill areas. The authors of those discussions have left no doubt that steelmaking, as we know it today, is highly dependent upon a supply of air which is free from dust and dirt.

Many highly efficient and continuously reliable turboblowers are maintained at peak performance because they are protected from dust-produced wear and erosion by an effective air cleaner. Electrical control and rotating equipment is kept cool and clean by an abundant supply of clean air. Other clean air needs in the modern mill include: control pulpits, clinics and hospital areas, crane cabs, offices, laboratories, accounting machine rooms, telephone switching rooms and many others. As a matter of fact the modern steel mill uses more air, by any measure, than any other material. Air is an essential part of every process from melting in the blast furnace to delivery of the finished product.

Since others have so adequately described and justified the need for air filtration, this discussion can, perhaps, be most helpful if it is confined to a careful examination of the equipment available, the basic principle of operation and the suitability of these devices for the various applications.

Air cleaning, as a specialized art, is relatively new when compared to steelmaking yet the air filter industry has, through diligent research and development, provided a wide variety of equipment. When properly applied these air cleaners can provide the results desired, even under severely adverse conditions. It is not yet practical to tabulate and equate all of the factors which are involved in the selection of an air cleaner and thus air filtration is still considered more of an art than an exact science.

No one air filter is suitable for all of the varying conditions which are encountered in a steel mill. Filters are generally classified on the basis of the fundamental operating principal and further subdivided according to the method of maintenance required. Of all the problems which arise regarding an air filter, the major one, and the subject of most of the indictments against them, is that they do in fact collect dirt!

Disposal of accumulated dirt in an air filter and simplification of maintenance procedures for keeping the filter in good operating condition is a problem which is the full-time concern of many well qualified engineers and designers in the filter industry. That they have made progress will become evident as the various types of filters are examined.

Any air filter can be placed into one of three classifications on the basis of its operating principal. These are:

1. Viscous impingement.
2. Strainer.
3. Electrostatic.

Each of these has some very definite limitations and one of them is efficiency. It would seem a simple matter to determine the efficiency of an air filter. By definition, efficiency is the ratio of output to input, and when

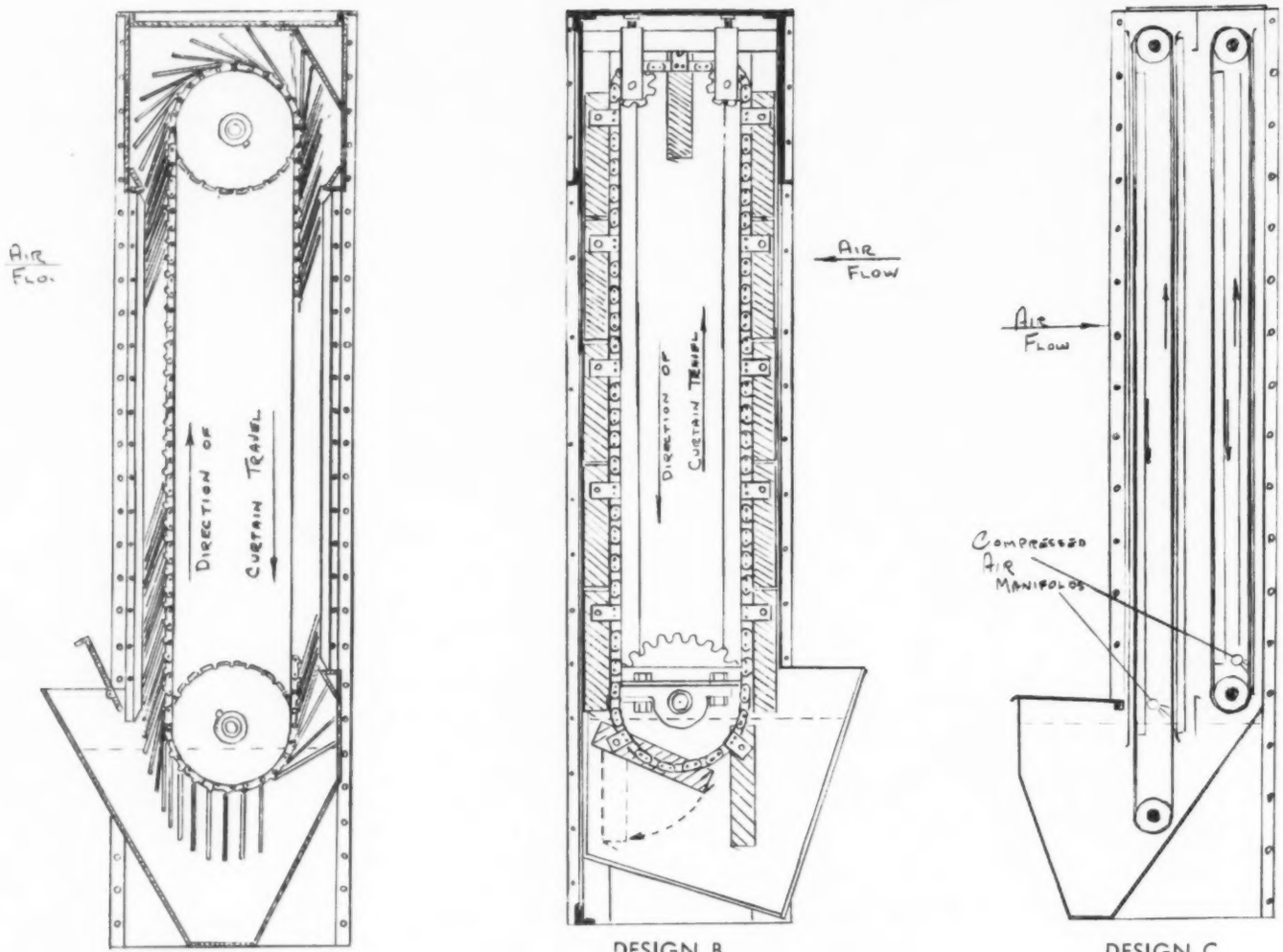


Figure 1 — These three mechanical filter designs are selfcleaning.

applied to air cleaning, "input" is the amount of dirt in the entering air and "output" is the dust retained by the filter. The filter industry has been taken to task on several occasions for the lack of uniformity in expressing filter performance but the difficulty is in finding a method of evaluating the dust content of the air. In an effort to standardize efficiency ratings the major air filter companies have banded together to form the Air Filter Institute (AFI) and they are now preparing a series of standardized filter testing procedures. The AFI rating for viscous filters has been released and has become the standard for the industry. Procedures and codes for testing other types are now in preparation. No known method exists for predicting, exactly, the efficiency of a given filter in a particular location.

Existing test procedures do, however, offer a ready method of comparative evaluation. The AFI test method just mentioned is a weight method test which uses a synthetic dust mixture to establish an arrestance rating and the rise in resistance with dust accumulation under accelerated conditions. The components of the test mixture are selected to simulate the type of dust that the filter is expected to remove when it is put into actual service. Unfortunately no typical dust exists which would simulate the composition of the dust predominant within the confines of a steel mill. Atmospheric dust is a complex mixture with a wide range of particle sizes that can vary in concentration with the location, wind direction, weather conditions, etc. To simulate atmospheric dust, the mixture used is a combination of carbon black, Arizona road dust and cotton linters. A known weight of the standard dust mixture is introduced to the air stream at a predetermined rate ahead of the filter and from the weight of dust samples taken on the clean air side of the filter a percentage of arrestance can be determined.

Another method of filter evaluation involves the measurement of the discoloring effect of the small particles which remain in an air stream after it has passed through a highly efficient filter. For the most part this procedure is reserved for electrostatic precipitators and high efficiency strainer type filters which would ordinarily show virtually 100 per cent collection by other test methods. With this method, measured air samples taken before and after the filter are drawn through white chemical filter paper. The relative discoloration of the targets is measured by a photo-electric device called a densitometer to establish values from which efficiency can be computed. An appreciation of the severity of this test can be gained by considering viscous filters which have a rating better than 80 per cent by weight

may show an efficiency of less than 12 per cent by the discoloration test method.

Still another method of filter testing involves the count method which is sometimes used to measure the effectiveness of an actual installation. A dust gun is used to obtain samples by drawing a measured quantity of air through a tiny orifice and causing it to impinge against a glass slide. The slide is then examined with a microscope at a magnification of about 40 diam and the dust particles within a ruled field are counted. The ratio of the number of particles before and after the filter determines the efficiency. The method favors larger particles and accounts for efficiencies of 97 per cent and higher. The count method is purely a spot test and is subject to many variables and cannot be relied upon to give duplicate results.

VISCOUS FILTERS

The foundation of the air cleaning industry was the invention of the viscous impingement unit filter in 1921. The original 20 x 20-in. unit filter quickly evolved into the automatic mechanical filter which is now so widely used.

More large volume installations of this type filter are in service today than any other. This type of unit is available in three basic designs as shown in Figure 1. Most successful has been Design A because of nonclogging features which permit it to completely relieve itself of the dirt accumulations which build-up on the curtain. While in the air stream the curtain forms a dense and highly effective filter media but it is so arranged that it separates in the oil bath for complete cleaning of each leaf or panel. With a die stamped louvered panel, this filter is especially suited to use in areas of heavy dirt concentrations. It is frequently used as a precleaner to strainer type filters or electrostatic precipitators. One installation in Southern Ohio serves as a precleaner to an electrostatic unit in the ventilation system for the control equipment of a skip hoist. Dirt concentrations are estimated to range up to 20 grains per thousand cu ft and this viscous impingement filter removes as much as 40 lb of dirt every eight hours. It is necessary to remove this material from the filter every shift and this is a maintenance problem of some magnitude, but consider the condition of that control room if air cleaners were not a part of the ventilating system.

Figure 2 shows this type of filter serving a blast furnace turboblower. Some turboblowers at various locations around the world are operating successfully without benefit of the protection of an air filter. Such installations are certainly few and far between and changing local conditions may terminate this success quickly as has happened on many occasions. Where air filters are used to remove dust and wear-producing dirt from the blast furnace supply, the louvered panel described above has been selected in all but few instances. Some of these installations have been in service for almost 20 years and it is an interesting fact that there is no record of a turboblower which has been protected by a properly cared-for filter of this type ever required rotor repairs due to dust-produced erosion. Such an outstanding record as this makes a decision to experiment with untried schemes most difficult and precarious.

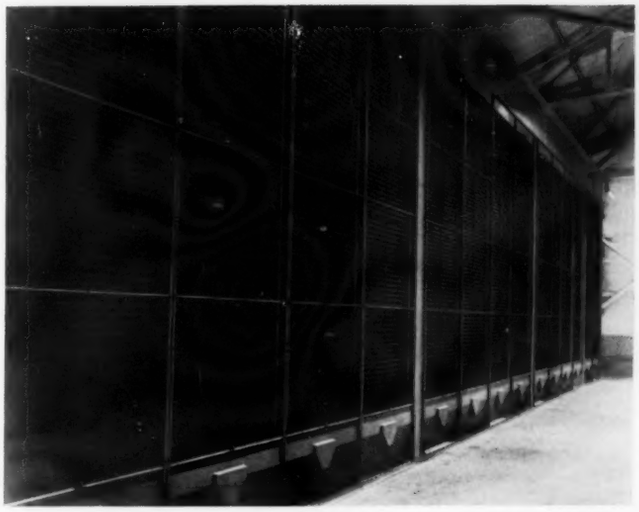


Figure 2 — This unit serving the blast furnace turboblower is an automatic viscous impingement design.

The automatic viscous filter has also been widely applied to electrical ventilation. Many operators find that satisfactory results are experienced even though this filter is not very effective in removing dirt particles less than five microns in diameter. This particle size limit is an inherent characteristic of the viscous impingement filter. In operation the viscous filter depends upon quick changes in the direction of air flow as the air passes through the media; because of their mass the dirt particles cannot follow this tortuous path and are thrown against the media surfaces where they are trapped and held in the viscous fluid. Particles smaller than five microns do not generally have sufficient mass to cause them to impinge.

It has become standard practice to under-rate these filters for mill applications in order to provide greater area for dirt collection and to provide more storage space for the accumulated sludge. Commercial practice is to use the manufacturer's catalog rating of 500 fpm but by wide experience it has been found that ratings of 350 to 400 fpm, depending upon the anticipated dirt load, result in a more satisfactory installation. This lower rating also provides a margin of safety against inadequate maintenance. If the dirt is not removed from the adhesive bath and is permitted to build-up to the point where the panels are dragged through it as the curtain rotates, plugging of the curtain will result and the higher velocities through the media will contribute to oil carry-over and entrainment. This situation is especially undesirable where the filter is used for electrical ventilation.

The required maintenance for this filter is the periodic lubrication of the driving mechanism, the removal of the collected dirt and replenishment of the charging fluid. Without question the most tedious task is the sludge removal. This is a necessary procedure and can be relieved only partially through the use of oil filtering equipment or settling tank systems. Such equipment has been adequately described previously and it suffices to say that the oil filter consists of a pump and enclosed cartridge which circulates the oil and accumulates the dirt into a concentrated package; the settling tank is a device for holding the oil in quiet storage for a sufficient time to permit the dirt to settle

out and form a dense sludge in the bottom of the storage vessel.

When operating at the proper capacity these filters offer a constant resistance to air flow of about 0.45 in. water column. This value does not vary because of the control mechanism which is timed to rotate the curtain once every 24 hours.

The initial cost of such a filter ranges from 6 to 7 cents per cfm depending upon the configuration of the unit. As a general rule higher filters cost less, wider ones more.

After half a decade of research and development which included field testing, under all conditions of commercial service as well as in steel mills, a radically new viscous filter was publically announced in 1955. That was the automatic renewable media filter which became widely accepted as a challenger to the mechanical filter.

In operation this unit consists of a supply roll of specially designed glass fiber mat, precharged at the factory with the proper amount of adhesive. With an arrangement of electric timers and electric drive mechanism this mat is continuously fed across the air stream. When a full load of dirt has been accumulated the used material is rerolled into a compact bundle for easy disposal. A remote signaling device keeps the operator informed at all times regarding the condition of the media supply and automatically alerts him when the media in any one section is exhausted. A filter of this type with a catalog capacity of more than 800,000 cfm supplying cleaned air to a mill motor room is shown in Figure 3.

This filter, while operating as a viscous impingement unit, is frequently referred to as "dry" because it does not require oil tanks, sludge removal, nor plumbing or piping. These features have made it especially popular for use with electrical ventilating systems because the problems of oil carry-over and danger from fire or water damage from sprinkler operation are completely obviated. The glass fibers are resistant to all corrosive agents and to rot, vermin and oxidation. A properly designed glass mat can collect and hold more than twice its own weight in dust and dirt. The amount of adhesive has been carefully balanced against the dirt holding capacity to insure adequate retaining power.

Figure 3 — This automatic filter installation has renewable components. It supplies almost 1,000,000 cfm.

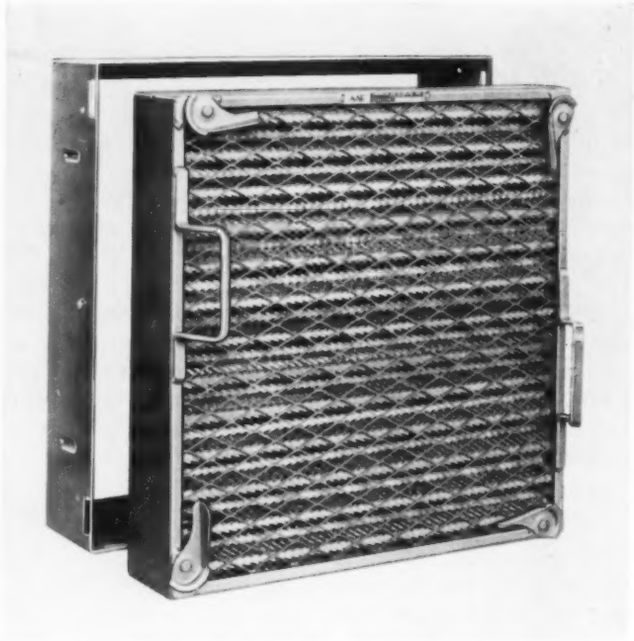


Figure 4 — This industrial unit filter is 20 × 20 × 4 in.

In areas of extreme dirt concentrations, the automatic renewable media filter may be misused because it does have a limited dirt holding capacity and excessive media usage may result from attempts to keep the operating resistance at a value between 0.35 and 0.5 in. water gage.

When used with a well-engineered glass mat these filters are entirely satisfactory for general purpose use and for electrical ventilation where it is not necessary to remove the very finest dust particles.

Occasional lubrication and periodic replacement of the media roll are the only maintenance requirements of this filter. The cost of the filter, control, and initial supply of media is about 5½¢ per cfm.

As with other viscous filters it is wise to select and size at approximately 80 per cent of the manufacturer's catalog rating. This type of equipment is offered by several manufacturers but for any specific requirement it is well to examine the item offered with extreme care. The actual cost of replacement media and the dust holding capacity are highly important factors in the operating cost experience.

Viscous unit filters of the disposable or of the washable type have little place in the steel mill. The disposable type might be used for very small air conditioners of the "window" unit variety and for occasional light duty with small isolated motors. For the most part, however, these filters have such a limited life that their replacement becomes a serious cost factor.

The all-metal washable filters in the 20 x 20-in. size have a capacity of 800 to 1200 cfm depending upon the design, and when used in a system of any sizable volume they can present a serious maintenance problem. When a load of dirt has been accumulated the filter must be washed in a bath of suitable detergent and then recharged with adhesive. This is such a time consuming operation that labor costs preclude consideration of these filters even though the first cost of such an installation is the lowest of all. Figure 4

shows a typical design of heavy-duty unit filter and its holding frame.

STRAINER FILTERS

Except for one design which will be discussed at length, the strainer type filter has little use in the mill. Conventional designs utilizing replaceable media in sheet form or in preformed cartridges are not capable of holding sufficient dirt to permit them to operate for a reasonable time between maintenance periods. Where a high degree of air cleaning is required such as a hospital, or a spectrographic or chemical laboratory, these filters are highly desirable as the final stage in a multi-filter arrangement. As a general rule such systems rarely use more than 10 to 20,000 cfm.

Of primary interest here is the strainer type filter which is known as the bag or tube filter. The earliest recorded attempt to clean air for any purpose dates to about 1865 when a coarse cloth material was fashioned into a bag and suspended in such a manner that the air was made to pass through the cloth and thus the entrained dirt was removed from the air stream.

From that ignoble beginning, cloth has been developed into a very effective medium for the collection of dust and dirt from an air stream. In dust collection, which differs from air cleaning in that the end product is dust rather than clean air, cloth collectors have been used for many years with great success on difficult problems. In the smelting of lead, zinc and some other nonferrous metals the "bag-house" is a fundamental and essential part of the equipment.

When removing contamination from the atmosphere, especially the heavy concentrations encountered in a steel mill, cloth has a tendency to "plug-up." In other words, the tiny openings in the woven or felted material hold some dirt particles so tenaciously that they cannot be removed by ordinary shaking or agitation. To circumvent this problem and permit the collector to be returned to something near its original resistance after maintenance, a scheme was devised to use the cloth as a support matrix for a supplementary fiber. In most of the tube type filters used today, the media supplement is carefully selected asbestos fibre. This material will coat cotton sateen and similar weaves without penetrating into the cloth and at the same time provide an excellent medium for the collection of dust. When the media supplement is properly applied these filters easily approach the effectiveness of electrostatic precipitators. Figure 5 describes this type of unit.

Normal rating varies between five and six fpm velocity through the actual cloth area and at this rating the filter will remove a high percentage of particles one micron in diameter or less. Many operators insist that the ventilating air for electrical rotating equipment be cleaned to this degree and the ability to do that plus, great capacity for dirt storage, freedom from oil, water, etc., and easy maintenance have directed the choice of this filter for service and a number of motor rooms and control areas.

The construction of these filters is such that air is forced through cloth tubes, ranging upward from about 3 ft in length and from 5 in. upward in diameter (an oval shape is sometimes used), in such a manner as to deposit the dirt in the media supplement inside the bag. The housing may be under positive or negative pressure as the local conditions dictate. Usually these filters operate in the range of 1½ to 3-in. pressure drop and thus they require considerably more fan horsepower than other types. Because of the low media velocities, great cloth area is required and this necessitates considerable installation space. Care must be exercised in choosing the bag material because some cloth is attacked by the weak acids which are formed when moisture in the air combines with sulphide or chloride fumes.

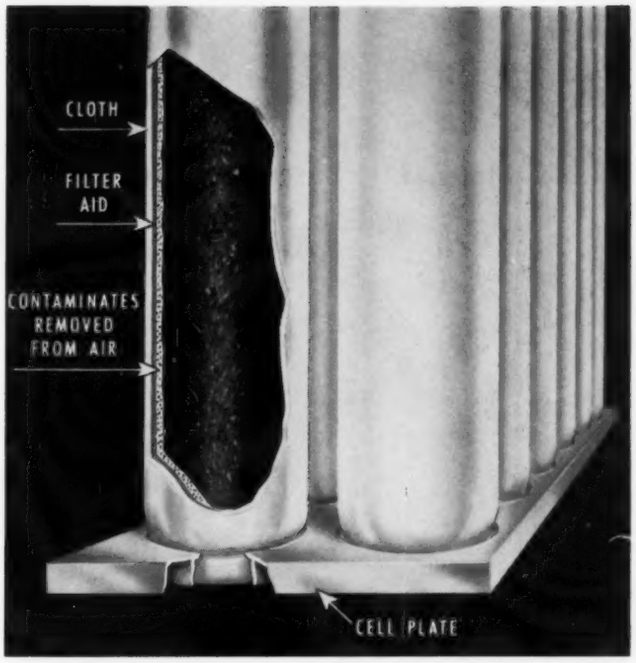


Figure 5 — Operation of tube type filter is shown by this cutaway.

It is also wise to consider that a rupture in a single tube may release a sizable volume of media supplement into the cleaned air stream. This type of filter is offered by several manufacturers and the original equipment cost averages about 18¢ per cfm. This, of course, does not include erection, the cost of which will vary with the individual design. Both mechanical and manual devices are available for metering and feeding the fibrous media supplement. The maintenance requirements consist of shaking down the dirt accumulation and used fibers, and recharging. This is done when the resistance through the unit reaches some predetermined value. Figure 6 shows an actual installation using this type of equipment to filter air for cooling motors in a roughing mill motor room. The lower section of the filter comprises a louvered intake for weather protection and houses the hoppers and conveyors employed in removing the spent filter aid and dirt. This unit is reported to have been in continuous operation since June, 1958, and has not required maintenance attention to this date. In a typical steel mill atmosphere operating experience indicates that from six months to one year of operation can be anticipated without attention or maintenance to the filter.

ELECTROSTATIC PRECIPITATORS

Because of their ability to remove extremely fine dust and dirt, electrostatic precipitators of several

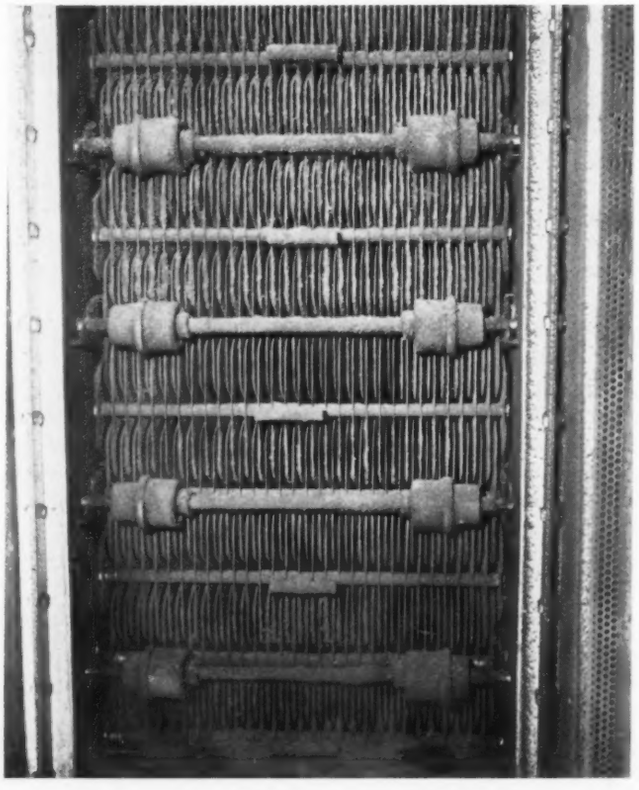
Figure 6 — This cloth tube filter installation is reported to have operated continuously since the middle of 1958 without being out of service.

designs have been widely applied to ventilating problems in the steel mill. The two-stage precipitator consists of an ionizing section where a charge of definite polarity is given to the dirt particles and a collecting section where the charged material is repelled from the plate of identical polarity and attracted to the one of opposite charge. This equipment was first introduced in about 1938 and soon became popular and widely applied in the mills. These filters are capable of removing air-borne particles as small as tobacco smoke which averages about 0.00001 in. in diameter. When used in areas of extremely heavy concentration the electrostatic precipitator sometimes poses an extraordinary maintenance problem because of its extremely high degree of effectiveness. The lowest cost electrostatic precipitator is the stationary plate type unit which is offered by several manufacturers.

While this filter leaves nothing to be desired in the way of effectiveness it does have one limitation which is important. The dirt is held on the plates of the collecting section by a coating of adhesive. It must be recognized that when a sufficient amount of dirt has been deposited to expend the holding capacity of that adhesive, additional material is not retained but is released into the air stream in the form of larger particles or agglomerates. Figure 7 shows the collector section of this type of filter with a maximum dirt load. To be continually effective the filter must be cleaned whenever such a load has been accumulated. Unfortunately, there is no direct means for signaling the condition of an electrostatic precipitator. A draft gage or similar device cannot be used because, even with heavy dirt accumulations, the resistance to air flow imposed by an electrostatic precipitator is not significantly increased. Frequent visual inspection, therefore, is necessary to assure proper operating conditions of the unit. Because of wide variations in the atmospheric contamination which is encountered within a steel mill, these inspections must be made regularly and it is absolutely necessary to remove the dirt when it has accumulated. A full load might be collected in a matter of hours while under other conditions the filter might remain in proper operating condition for days or even weeks. In general the maintenance procedure involves washing the accumulations away with hot water or, with special adhesives, with cold water. After the dirt is washed away and the filter has returned to its approximately new condition, it must be recoated with the adhesive which will retain the dirt when it is again placed in service. These cleaning operations can be simplified to some extent by using automatic washing and oiling accessories. Dependent upon the accessories which are chosen, the industrial version of this type of filter is available at a price which varies between 15¢ and 18¢ per cfm.

It is well to point out that the most recent development with regard to this type of filter has been to reduce the physical size of the unit by increasing the velocity at which the air passes through it. In the industrial type, the maximum velocity is generally considered to be approximately 333 fpm. This new design permits operation at velocities up to 600 and sometimes 700 fpm. Such a unit should be selected with extreme caution for steel mill service. The danger arises from the fact that the high velocity equipment has a much narrower plate spacing. In some designs this spacing is little more than $\frac{1}{8}$ and the applied potential is as much as 4000 volts. Since the dirt holding capacity

Figure 7 — Stationary plate type filter as shown has an excessive load of dirt.



of the filter is limited to the plate surface which is available and the continual operation of the filter depends upon complete insulation of the collecting plates, it is a simple matter to appreciate the importance of the plate spacing. If only $\frac{1}{8}$ or $\frac{3}{16}$ in. is available between the plates it is obvious that an accumulation of $\frac{1}{16}$ in. is sufficient to short the unit out of service. Figure 8 describes a stationary plate type precipitator complete with automatic washing and oiling equipment which is suitable for steel mill service.

A significant advance in the reduction of maintenance attention to electrostatic precipitators occurred when the self-cleaning electrostatic precipitator was introduced about 1940. Because of its self-cleaning action, the dirt load which is accumulated on the plates is continuously removed and the dirt is deposited in a reservoir at the bottom of the filter. The self-cleaning feature relieves the operator of the responsibility of continual inspection and prolongs the maintenance period while at the same time providing the highest degree of air cleaning. The charging liquid which is used with these filters is fire-proof and noncombustible so that any hazard which might be involved in their use is greatly minimized.

With either the stationary plate type precipitator or with the self-cleaning unit, experience has shown the desirability of using a prefilter or a roughing filter as it is sometimes called. This prefilter equipment collects a great amount of the dirt load by removing the larger particles from the air stream, thus reserving the effectiveness of the electrostatic precipitator for the extremely fine particles of dirt and smoke. Obviously, such an arrangement will greatly increase the time between maintenance periods and will assist in keeping the precipitator in good condition at all times. With the self-cleaning unit it is now the manufacturer's standard practice to provide a built-in prefilter to accomplish this. For the average installation this filter has an initial cost of about 22 cents per cfm.

It is the constant aim of the air filter industry to provide equipment which demands the least possible amount of maintenance attention. Investigation and studies in this direction have resulted in an entirely new concept of dirt collection and storage. This equipment which is best described as electrostatic agglomerator and storage section is shown in Figure 9. In this unit the dirt particles are ionized to give them a definite polarity and they are then precipitated on an uncoated collector plate as they pass through the unit in the air stream. Tiny particles adhere to one another by mechanical forces of cohesion, and when a sufficiently large agglomerate has accumulated it is dislodged from the plates by the action of the air stream and carried into the final or storage section. The dirt storage part of the filter consists of a blanket of glass fibers designed to hold large quantities of dust and dirt. As with the replaceable media filter which was described earlier, the fiber blanket is so arranged that it is automatically fed across the air stream. The used glass together with its accumulated dirt load is automatically rolled into a compact package which is readily accessible and easy to remove. Because the electrostatic portion of this filter accumulates no dirt load, it operates for extremely long periods without maintenance attention. Other than an occasional wiping down of the ionizer struts, no routine maintenance or inspection is required. When it becomes necessary to furnish a new supply of material for the storage section, an automatic signal is flashed to the operating floor. Although this type of filter has been available to the steel industry for only four or five years, its superiority has been recognized and it has been widely applied to large volume

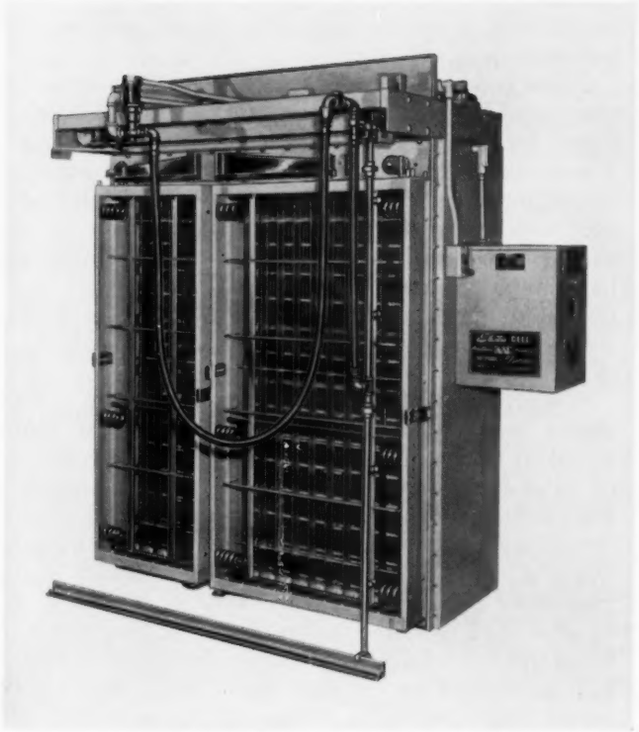
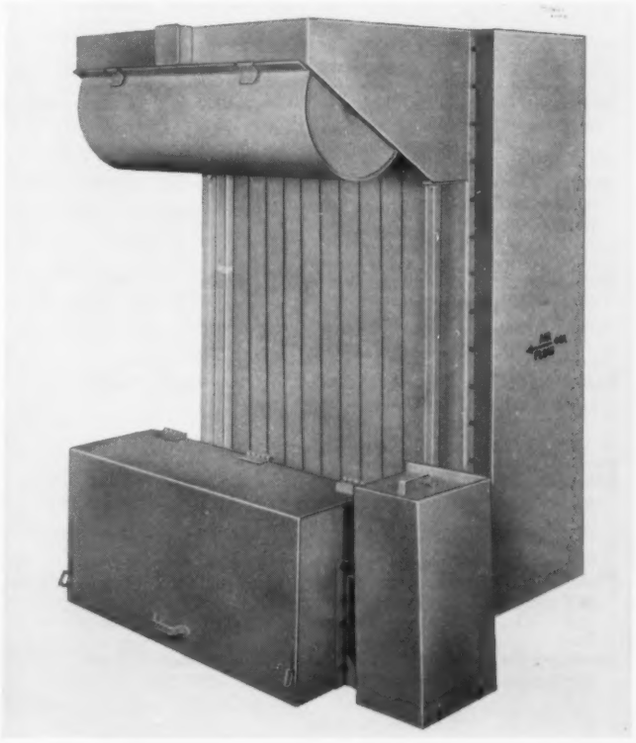


Figure 8 — Although this unit is small it is equipped with automatic washing and oiling equipment.

Figure 9 — The electrostatic agglomerator is a new concept in dirt collector and storage.



ventilating systems especially those serving mill motor rooms.

There is no reason why this type of filter cannot be considered for general purpose work, in fact it is ideally suited for application where the atmosphere contains a wide range of dirt concentration. It is equally effective under light or heavy load conditions and is the exception to the rule that an electrostatic precipitator should be equipped with a prefilter. The prefilter can be eliminated because large particle material is intercepted by the storage section yet imposes no particular load on the ionizing and agglomerating portions of the filter.

When combining equipment to achieve the agglomerator principle of operation, extreme care should be taken to thoroughly investigate the design features of all of the components. The electrostatic portion of the filter should not contain any areas which offer an opportunity for dirt to lodge and build-up to the point where it could short circuit the unit. Another highly important consideration is the type of insulating material which is used and the length of leak path which the insulators offer. In order to achieve long term operation it is essential that the insulators, which unavoidably collect some amount of surface dirt, be of such quality and size as to insure as little electrical leakage as possible. With regard to the storage section a unit must be selected which has fully reliable control and driving mechanism and it is fundamental to select a glass fiber blanket which has an extraordinary dirt holding capacity. If these points are not fully considered it is entirely possible to obviate the long term freedom from maintenance which is the basic reason for selecting such a filter.

In general the agglomerating filters are available at slightly less cost than the self-cleaning electrostatic precipitator or about 18¢ per cfm.

SUMMARY

It is a well recognized fact that the chemical composition, the concentration and the particle size distribution of the air-borne contaminants found within the confines of a steel mill are peculiar to the industry. It was mentioned earlier that it is not yet possible to assure precisely the performance of a filter in the steel mill atmosphere. For example, a preponderance of scarfing fumes, which is a material that is almost impossible to filter from an air stream by ordinary means, can reflect poor performance of a filter which would ordinarily be expected to give excellent results. Because of this situation it is difficult, if not impossible, for the air cleaning specialist to make positive predictions regarding the performance or effectiveness of a given piece of equipment. At least one steel company is making a concentrated effort to determine what dust conditions within various ventilated spaces are acceptable. Since much of the information which they seek must be gained through the difficult and tedious method of trial and error, their progress is understandably slow, as greater interest is displayed in air cleaning problems. It is entirely possible that within the next few years a series of standards for air cleaning in the steel mills will be established and that air cleaning equipment can then be tested and evaluated as to its performance and effectiveness on steel mill dirt. For the time being, however, one must be satisfied to remove as much of the dirt as possible and the actual choice of the type of filter for a specific job must be based on a careful analysis of all of the factors involved.

TABLE I
Filter Comparison Chart for Steel Mill Service

Type of filter	Suitable service	Efficiency by weight	Efficiency by discoloration	Dust capacity	Maintenance required	Operating resistance	Approximate new cost (1959)	Sources
Automatic viscous	Turboblower Electrical ventilation General purpose	Good	Poor	Very great	Sludge removal Oil replacement Lubrication	0.45-in. wg constant	6¢ to 7¢ per cfm	3 or more
Automatic renewable media	Electrical ventilation General purpose	Good	Poor	Great	Media replacement Lubrication	0.35 to 0.50 in. wg Adjustable and constant	5½¢ per cfm	3 or more
Viscous unit filters	Miscellaneous light duty	Good	Poor	Low	Replace or wash and re-oil	Constantly increases from approximately 0.12 in. wg	1¢ per cfm	Many
Supplemented cloth media	Electrical ventilation General purpose	Excellent	Good	Very great	Remove dirt and filter aid and recharge filter aid	Constantly increases to about 3 in. wg	18¢ per cfm	3 or more
Electrostatic stationary plates	Electrical ventilation Hospitals and laboratories	Excellent	Good	Limited by plate area	Wash and re-oil (can be automatic) Regular inspection required	0.25 in. wg constant	15¢ to 20¢ per cfm	2 or more
Electrostatic self-cleaning	Electrical ventilation Hospitals and laboratories	Excellent	Good	Great	Remove sludge Wipe ionizer Lubricate	0.25 in. wg constant	22¢ per cfm	One
Electrostatic agglomerator	Electrical ventilation Hospitals and laboratories General purpose	Excellent	Good	Great	Media replacement Wipe ionizer Lubricate	0.4 to 0.5 in. wg Adjustable and constant	18¢ per cfm	One

It is conservative to estimate that the current expenditures for air cleaning equipment in the steel industry at about $1,000,000 annually. This figure does not include the cost of erection or installation. An untold amount is being spent for maintenance labor and materials. The source of many complaints regarding the operation of air cleaning equipment can be traced to faulty or inadequate maintenance. The air filter does not in itself make a visible contribution to the quality or quantity of steel which is produced. Because of this there is a natural tendency to neglect them. This tendency is frequently exaggerated by the remote location of the filters. They are seldom seen. Even with diligent supervision and conscientious workmen it is essential that the maintenance department be provided with the type of equipment which best fits their existing facilities and practices. Frequently an educational program is required to impress upon the operating personnel the true value of the air cleaning equipment and the need for maintaining it in good condition at all times. A well cared for and properly applied air filter will pay for itself in a short period of time and will continue to give reasonable return on the initial investment, and to provide the required protection of men and machines from the ravages of dust and dirt.

Discussion

PRESENTED BY

EARL R. KOENIG, Application Engineer, Sturtevant Div., Westinghouse Electric Corp., Pittsburgh, Pa.

DR. ALLEN D. BRANDT, Chief Industrial Hygiene Engineer, Bethlehem Steel Co., Bethlehem, Pa.

C. D. WRIGHT, Steel Mill Application Specialist, Air Filter Div., American Air Filter Co. Inc., Louisville, Ky.

Earl R. Koenig: We can appreciate the thought behind the statement that the major problem and most common indictment against filters is that they do in fact collect dirt. All too often overlooked is the fact that the accumulated dirt has to be disposed of somewhere. The annual accumulation can be surprising. For example a filter handling 200,000 cfm of air, which is typical of an average motor room ventilating system, can be expected to collect in the neighborhood of two tons in one year of operation. Depending on the type of filter used, this accumulated amount of dirt and/or expended media, sludge or filter aid, should be taken into account when planning a disposal method.

In choosing filters in ventilating systems for electrical equipment, especially for d-c machines, it is advantageous to remove as many of the particles under five microns as possible as well as the larger particles. Particularly vulnerable are the creepage path areas behind the commutator necks and below the lower coil sides as well as the rear mica vee rings of the commutator. Carbon dust is an electrical conductor whether dry or moist, but even a layer of nonconductive dust accumulated over a period of time may become a conducting path in the presence of moisture.

Also, abrasive particles which become imbedded in the brush face result in removal of the desired surface film, scoring of the commutator surface and prevention of free movement of the brush in its holder thus causing poor contact and sparking.

We believe that the above problems should be taken into account in the selection of any filter for best overall results.

Dr. Allen D. Brandt: It is difficult to understand the author's statement that the dust count method of filter efficiency testing favors larger particles. Actually, any meaningful method of determining the number concentration of dust in the air gives equal weight to each particle irrespective of size. It is the weight concentration measuring procedures that favor large particles, not counting methods. For this reason collecting efficiency results determined by counting methods are lower for most air cleaners than efficiencies determined by weight. How much lower such efficiencies are depends in the main on: (1) how selective as to particle size is the filter, and (2) the particle size distribution of the particulate matter in the air being filtered.

The reason for the lower efficiencies by count is obvious. Most air cleaners retain the larger particles more readily than the smaller ones. Since a 10-micron particle of a given material weighs 1000 times as much as a 1-micron particle of the same material, a few particles at the top of the size distribution curve will outweigh many particles at the other end of the curve. Consider for example, an artificial dust-in-air suspension containing an equal number of 10-micron particles and 1-micron particles. Any filter which removes all 10-micron particles but no 1-micron particle would be 50 per cent efficient by count, but 99.9 per cent by weight. The large number of tests we have made on air cleaners of various kinds bears out these theoretical considerations. In fact the results obtained by count parallel those obtained by the discoloration method referred to by the author, for obvious reasons.

It should be pointed out also that it is not the count method that is a spot test-type evaluation. All the count method does is quantitate the amount of dust in a sample. Obviously, if a grab sampler is used the result is of the spot test type and therefore subject to various inaccuracies. In our tests the sampling is done for hours, rarely less than eight and frequently as long as 24. Under such conditions the results are completely reliable and provide very useful data which cannot be obtained in any other way. In fact, we feel that both weight and count efficiency results are needed on any filter to describe its dust retaining characteristics in a meaningful way.

C. D. Wright: The count method we described has many modifications and certainly it has been improved considerably since first introduced. Any count method requiring optical systems must favor larger particles because of optical limits. Even with dark field illumination, it is doubtful that particles smaller than 0.5 micron in diameter can be observed. Certainly they cannot be sized with any degree of accuracy.

It is fully agreed that long period sampling as described by Dr. Brandt is more accurate and highly desirable. ▲

TENTATIVE LIST OF PAPERS

To be presented at

AISE Western Meeting

THE STATLER HILTON
LOS ANGELES, CALIF.

February 27, 28, and March 1, 1961

"Operational Results of Automatic Gage Control on a Hot Strip Mill," by R. M. Peeples, Supervisory Engineer, and E. H. Christian, Engineer, Control Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

"Ceco's Ochiltree Works Modern Electric Furnace Bar and Merchant Mill," by W. B. Jacobsen, Works Manager, Ochiltree Works, Ceco Steel Products Corp., Lemont, Ill., and Lawrence S. Barker, Jr., Project Manager, The Rust Engineering Co., Birmingham, Ala.

"Automation and Process Control in Soviet Iron and Steel Industry," by W. E. Miller, Manager, and R. M. Sills, Metal Rolling and Processing Engineering, Industrial Engineering Operation, General Electric Co., Schenectady, N. Y.

"Solutions Basic to L-D Plant Layout Problems," by J. W. Irvin, Project Engineer, Kaiser Engineers, Oakland, Calif.

"The Power Distribution System of an Integrated Steel Plant," by Donald Stewart, Jr., Electrical Maintenance Engineer, Electrical Maintenance Dept., Kaiser Steel Corp., Fontana, Calif.

"The Production and Uses of Aluminized Steel," by John D. Sprowl, Research Engineer, Dept. of Metallurgical Research, Kaiser Aluminum & Chemical Corp., Spokane, Wash.

"Natural Gas Injection into the Blast Furnace at Lone Star Steel Co.," by Fred W. Farmer, Combustion Engineer, and J. C. Moreland, Junior Combustion Engineer, Lone Star Steel Co., Lone Star, Texas

"Rolling of Thin Tinplate," by Dr. Morris D. Stone, Manager, Development, United Engineering and Foundry Co., Pittsburgh, Pa.

"Outstanding Application Developments in Mill Electric Drive Systems," by W. H. Dauberman and S. V. Stickler, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

"Use of the Open Coil Process to Change Composition and Produce Improved Sheet Steels," by John A. Bauscher, Vice President—Research, Lee Wilson Engineering Co., Inc., Cleveland, Ohio

"Oxy-Fuel Processes Increase Steelmaking Rates," by E. F. Kurzinski, Manager, and R. D. Jones, Development Engineer, Applied Research and Development Div., Air Products Inc., Allentown, Pa.

"A Training Program for Key Electrical Maintenance Employees," by Dr. Joseph S. Kopas, Training Counselor, Republic Steel Corp., and Director, Human Engineering Institute, Cleveland, Ohio

"The Story of Atlantic City," by W. F. Pruden, Chief Engineer, Columbia-Geneva Steel Div., United States Steel Corp., San Francisco, Calif.

"Application of Modern Control Concepts—Utah Pipe Mill," by F. T. Hickenlooper, Plant Engineer, Consolidated Western Steel Div., United States Steel Corp., Provo, Utah

INFORMAL STAG DINNER—February 28

INSPECTION TRIP—March 1
Kaiser Steel Corp., Fontana, Calif.

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Write direct for hotel reservations to The Statler Hilton, Los Angeles, Calif., giving time of arrival and type of accommodations desired. Reservations should state that they are for the AISE Western Meeting.

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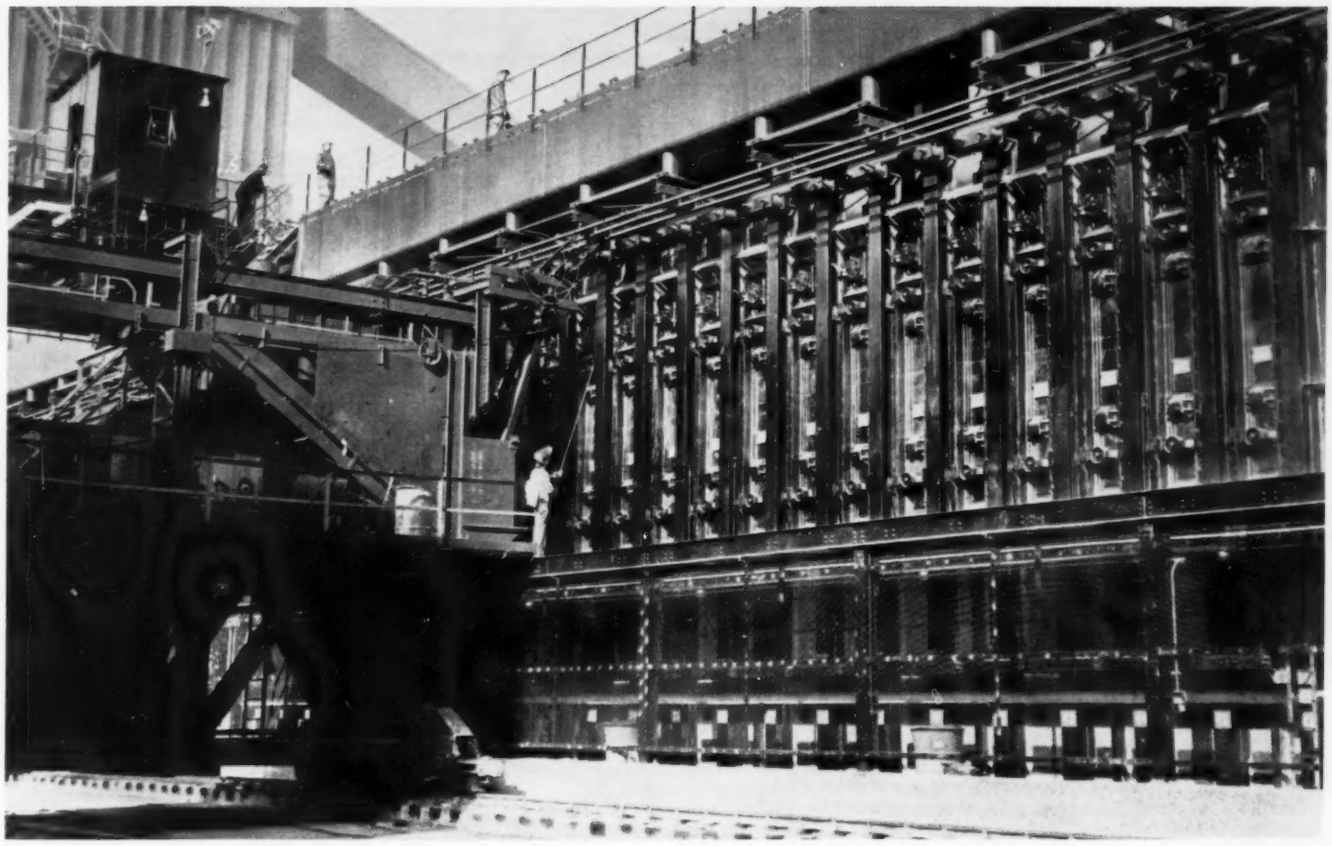


Coke And By-Products In 1959

by I. E. MADSEN

Data and material in this report are based on information or quoted from Mineral Market Reports M.M.S. No. 3095 dated July, 1960 and M.M.S. No. 3132 dated October 10, 1960.

PRODUCTION of coke in 1959 increased four per cent over 1958 but was 30 per cent less than the record output of 1951, according to the Bureau of Mines, United States Department of the Interior. The increase over 1958 was achieved in spite of a 116-day shutdown of the iron and steel industry which caused nearly all of the furnace oven-coke plants to bank their ovens or operate them at greatly reduced rates. Oven-coke plants operated at a high rate through June and production at furnace plants averaged 91 per cent of capacity while merchant plants averaged 70 per cent. The steel strike, beginning July 14, drastically reduced coke output and furnace plants operated at only 21 per cent of capacity until the settlement of the strike on November 7. The tremendous drop in requirements of blast-furnace coke reduced purchases from merchant plants and the rate of production of merchant plants for the July to November period averaged about 60 per cent of capacity. Coke production rose rapidly following the end of the work stoppage in November and by the end of the month, furnace plants were operating at about 80 per cent of capacity and merchant plants increased their operating rate to about 70 per cent. In December, production rates continued to climb and by the end of the year furnace plants were producing at about 90 per cent of capacity and merchant plants reached 73 per cent, the highest production rate since February, 1959, for this group. Slot-type ovens supplied 98 per cent of the coke produced in 1959.

Production of beehive coke in 1959 nearly doubled the 1958 output, mainly because of the strong demand for

TABLE I
Statistical Trends of the Coke Industry in the United States

	1937	1956	1957	1958	1959
Production					
Oven coke, net tons	49,210,748	71,992,242	73,860,692	53,005,730	54,789,276
Beehive coke, net tons	3,164,721	2,462,022	2,090,029	598,372	1,074,296
Total, net tons	52,375,469	74,454,264	75,950,721	53,604,102	55,863,572
Per cent oven coke	94.0	96.8	97.2	98.9	98.1
Stocks of coke, end of year, net tons	2,595,287	2,334,441	3,147,776	3,823,364	4,682,436
Exports, all coke, net tons	526,683	655,717	822,244	392,817	460,222
Imports, all coke, net tons	286,364	130,955	117,951	121,517	123,255
Indicated consumption, all coke, net tons	51,271,929	73,324,094	74,432,093	52,658,214	54,667,533
Furnace coke, net tons	36,751,969	66,311,598	68,769,998	47,597,825	49,377,383
Foundry coke, net tons	2,038,822	2,951,776	2,588,860	2,145,018	2,621,176
Other industrial coke (including producer and water gas), net tons	4,597,894	3,639,131	3,116,438	2,591,353	2,234,828
Domestic coke, net tons	8,107,518	912,436	662,625	603,876	470,367
Carbonizing equipment					
By-product ovens in existence, end of year	12,718	15,923	15,897	16,244	15,993
Beehive ovens in existence, end of year	12,194	9,659	9,519	8,682	7,448
By-product ovens under construction, end of year	259	631	611	149	
Cost of coal charged, oven-coke plants average per ton	$3.74	$9.35	$9.91	$9.89	$9.88
Prices of coke:					
Average realization on oven coke sold (merchant sales)					
Furnace coke	$4.34	$15.70	$16.08	$15.37	$15.92
Foundry coke	$8.47	$26.50	$28.77	$28.93	$30.33
Other industrial coke (including water gas)	$6.08	$14.35	$15.74	$16.10	$15.84
Domestic coke	$6.53	$16.30	$17.12	$17.14	$17.22
Yield of by-products per ton of coal charged					
Tar, gal	8.67	8.15	8.32	8.83	8.41
Ammonium sulphate or equivalent, lb.	21.84	19.28	19.56	19.86	18.70
Crude light oil, gal	2.86	2.92	2.94	2.95	2.81
Surplus gas sold or used (does not include gas used in heating oven), M cu ft	6.66	6.49	6.55	6.62	6.60
Average gross receipts for by-products, per ton of coke produced					
Crude tar sold and used (exclusive of amount used by producers for own use in refining and topping and exclusive of tar derivatives)	$0.502	$0.912	$1.070	$1.11	$1.09
Ammonia and its compounds	$0.326	$0.448	$0.409	$0.440	$0.47
Crude light oil and its derivatives (including naphthalene)	$0.435	$1.213	$1.064	$0.96	$0.88
Surplus gas sold or used	$1.483	$2.102	$2.23	$2.33	$2.26
Total coal-chemical materials (including breeze)	$2.974	$5.73	$5.87	$6.11	$5.73

blast-furnace fuel during the first six months. Beehive production did not bounce back after the strike as did oven coke and the December, 1959, production was only 76 per cent of the monthly average output for the first six months. One of the factors that hampered beehive production in December was the large stock of oven coke that accumulated at many of the furnace plants during the strike. Stocks of coke at furnace plants nearly doubled between June 30 and November 30. Stocks of coke at merchant plants rose more than 500,000 tons or 40 per cent during the same period. An all-time peak, slightly above 5,000,000 tons, was established in November. This large reserve of coke, particularly at furnace plants, cut down the need for beehive coke.

The apparent consumption of coke for all purposes in the United States in 1959 rose four per cent over the 1958 total but was 23,425,820 tons or 30 per cent below the high record in 1951. As in preceding years, iron blast furnaces consumed 89 per cent of the national coke consumption; iron and steel foundries, five per cent; producer- and water-gas manufacture, less than one per cent; other industrial uses (nonferrous smelting, chemical processing, rock wool manufacture, etc.), four per cent; residential heating, one per cent; and one per cent was exported. The quantities used in metallurgical applications (blast furnaces and foundry) and for other industrial purposes increased; whereas less was used to manufacture gas and for residential heating.

Production of coke screenings or breeze increased two per cent in 1959 over 1958. Until recent years this material was used almost exclusively as a power-plant fuel. In recent years, however, outlets for breeze have changed, principally because of the increased demand for agglomerating iron ore and smelting phosphate rock. In 1959, only 32 per cent of the breeze output was used for raising steam, 26 per cent in agglomerating plants at iron and steel works, and 38 per cent used or sold for miscellaneous industrial applications, including the manufacture of elemental phosphorus. The increased demand for breeze stimulated prices and the average value per ton of breeze sold in 1959 was 98 per cent higher than the 1947 to 1949 period. Most of the breeze used in phosphate furnaces in the western states and in Florida was shipped by rail over great distances which added considerably to the delivered price of breeze at such installations.

Although slot-type ovens carbonized 1,907,081 more tons of coal in 1959 than in 1958, production of ammonia, tar and light oil decreased while gas output increased. The output of these basic chemical raw materials was held down because the yields of all of these products were lower than in 1958. The decrease in output of the basic chemical products also reduced production of the principal derivatives of tar, light oil and ammonia. There was only limited production of coal chemicals during the steel strike. The strike did not cause any shortages of tar and light oil products such as creosote oil, benzene, toluene and xylene, but supplies of naphthalene became critical. Unlike benzene, toluene and xylene, which were produced in large volume by the petroleum industry, the sole source of naphthalene supply was from coal carbonization in the United States

TABLE II

Salient Statistics of the Coke Industry in the United States in 1959

	By-product	Beehive ovens	Total
Coke produced:			
At merchant plants, net tons	6,849,786	①	①
At furnace plants, net tons	47,939,490	①	①
Total, net tons	54,789,276	1,074,296	55,863,572
Screenings or breeze produced, net tons	3,710,968	74,217	3,785,185
Coal charged into ovens, net tons	77,722,907	1,827,474	79,550,381
Average value of coal per ton	$9.88	$6.10	$9.80
Average yield in per cent of total coal charged:			
Coke	70.49	58.78	70.22
Breeze (at plants actually recovering)	4.78	6.23	4.80
Ovens:			
In existence January 1	16,244	8,682	...
In existence December 31	15,993	7,448	...
Annual coke capacity December 31, net tons	81,447,700	4,368,800	85,816,500
Coke used by producer:			
In blast furnaces, net tons	45,836,378	47,430	45,883,808
In foundries, net tons	225,968	...	225,968
To make producer gas, net tons	93,374	...	93,374
To make water gas, net tons	84,669	...	84,669
For other purposes, net tons	486,846	...	486,846
Coke sold (commercial sales):			
For blast furnace use, net tons	2,783,159	750,247	3,533,406
For foundry use, net tons	2,455,484	8,396	2,463,880
For manufacture of water gas, net tons	48,362	1,261	49,623
For other industrial use, net tons	1,460,956	266,730	1,727,686
For domestic use, net tons	472,458	1,030	473,488
Disposal of screenings or breeze			
Used by producers:			
For steam, net tons	1,209,412	...	1,209,412
For sintering iron ore, net tons	982,799	...	982,799
For other purposes, net tons	458,003	...	458,003
Sold, net tons	899,956	85,508	958,464
Average receipts per ton sold (merchant sales):			
Furnace coke	$15.92	$15.13	$15.75
Foundry coke	$30.33	$16.20	$30.28
Water-gas coke	$18.16	$13.00	$18.03
Other industrial coke	$15.75	$12.85	$15.30
Domestic coke	$17.22	$14.60	$17.22
Screenings or breeze	$8.01	$2.03	$7.49
By-products produced:			
Tar, gal	653,728,164	...	653,728,164
Ammonium sulphate or equivalent, lb ③	1,433,406,000	...	1,433,406,000
Gas, M cu ft	804,600,058	...	804,600,058
Burned in coking process, per cent	34.6	...	34.6
Surplus sold or used, per cent	64.1	...	64.1
Wasted, per cent	1.3	...	1.3
Crude light oil, gal	213,036,193	...	213,036,193
Yield of by-products per ton of coal:			
Tar, gal	8.41	...	8.41
Ammonium sulphate or equivalent, lb ③	18.70	...	18.70
Gas, M cu ft	10.35	...	10.35
Crude light oil, gal	2.81	...	2.81
Coal used per ton of coke, tons	1.42	1.70	1.42
Value of coke at ovens	$976,343,886	$15,740,926	$992,084,812
Value of screenings or breeze	$25,549,658	$155,529	$25,705,187
Value of by-products sold:			
Tar sold and used by producer	$56,727,402	...	$56,727,402
Ammonia (sulphate and liquor) ③	$25,746,818	...	$25,746,818
Gas (surplus)	$123,123,822	...	$123,123,822
Crude light oil and derivatives	$48,171,365	...	$48,171,365
Other coal-chemical materials ②	$34,384,315	...	$34,384,315
Total value of coke and breeze produced and coal-chemical materials sold and tar used by producer	$1,290,047,266	$15,896,455	$1,305,943,721

① Not separately recordered. ② Includes di- and mono-ammonium phosphate, ammonium thiocyanate, ammonium sulphate, and ammonia liquor (NH_3 content). ③ Naphthalene, tar derivatives and miscellaneous coal-chemical materials.

and abroad. Imports of crude naphthalene from European countries averaged over 90,000,000 lb for the years 1955 to 1959 and totaled 59,000,000 lb in 1959. Although naphthalene requirements were expected to increase steadily in future years, imports might be greatly reduced because of rapidly rising requirements abroad. The uncertainty of imports and the expected substantial increase of future requirements directed attention to petroleum as another source of supply. Several petroleum companies conducted research and laboratory studies to develop processes to produce petroleum naphthalene for the past several years, and one company early in 1960 was planning on constructing a large commercial plant.

The total value of coal carbonized was $779,227,794 in 1959. The value of all coal-chemical materials used and/or sold, and coke and breeze produced amounted to $1,305,943,721 or 68 per cent more than the value of the coal. The value of coke and breeze amounted to nearly 78 per cent of the value of all products while coal-chemical materials, including surplus gas, made up the balance.

TABLE III

Summary of Oven-Coke Operations in the United States in 1959, by States

State	In existence Dec. 31*		Coal carbonized, net tons	Yield of coke from coal, per cent	Coke produced, net tons	Value of coke at ovens	
	Plants	Ovens				Total	Per ton
Alabama	7	1,488	6,728,381	72.79	4,897,884	$96,476,915	$19.70
California, Colorado and Utah	4	860	3,728,579	61.99	2,311,248	57,105,887	24.71
Illinois	6	507	2,984,483	68.52	2,044,977	37,792,888	18.48
Indiana	5	2,191	9,575,999	71.98	6,892,972	118,009,645	17.12
Kentucky, Tennessee and Texas	4	380	2,453,771	71.17	1,746,449	30,293,063	17.35
Maryland	1	758	3,172,447	75.72	2,402,312	†	†
Massachusetts	1	108	493,313	68.59	338,387	†	†
Michigan	4	769	4,426,269	73.77	3,265,252	60,750,009	18.60
Minnesota	3	241	998,756	69.64	695,536	14,475,829	20.81
New Jersey	1	230	845,365	72.75	615,001	†	†
New York	3	830	4,373,476	69.67	3,046,813	51,511,184	16.91
Ohio	14	2,390	12,445,985	71.03	8,840,750	147,945,010	16.73
Pennsylvania	14	4,133	19,880,636	69.19	13,755,846	227,773,358	16.56
West Virginia	4	742	4,451,915	69.12	3,077,138	50,967,671	16.56
Connecticut, Missouri and Wisconsin	3	366	1,163,532	73.80	858,711	20,867,045	24.30
Undistributed	..	...	...	...	...	62,375,382	18.59
Total 1959	74	15,993	77,722,907	70.49	54,789,276	976,343,886	17.82
At merchant plants	20	2,249	9,568,131	71.59	6,849,786	146,063,542	21.32
At furnace plants	54	13,744	68,154,776	70.34	47,939,490	830,280,344	17.32
Total 1958	77	16,244	75,815,826	69.91	53,005,730	966,794,538	18.24

* Excludes plants retired permanently during year. † Included with "Undistributed" to avoid individual company figures.

TABLE IV

Summary of Beehive-Coke Operations in the United States in 1959, by States

State	In existence Dec. 31*		Coal carbonized, net tons	Yield of coke from coal, per cent	Coke produced, net tons	Value of coke at ovens	
	Plants	Ovens				Total	Per ton
Pennsylvania	35	6,080	1,140,511	62.52	713,150	$10,415,475	$14.60
Kentucky, Virginia and West Virginia	10	1,368	686,963	52.57	361,146	5,325,451	14.75
Total 1959	45	7,448	1,827,474	58.78	1,074,296	$15,740,926	14.65
Total 1958	53	8,682	1,015,416	58.93	598,372	8,395,199	14.03

* Excludes plants retired permanently during year.

PRODUCTION OF COKE

In 1959 production of by-produced coke averaged 150,000 tons daily compared with 145,000 in 1958. Beehive coke averaged 2950 tons in 1959, almost double the 1640 tons daily in 1958. Pennsylvania was by far the most important state as far as production was concerned and produced 13,755,846 tons. Following Pennsylvania were Ohio, Indiana and Alabama with 8,840,750, 6,892,972 and 4,897,884 tons, respectively. Immediately following these were three more states with a little over 3,000,000 tons each; namely, West Virginia, Michigan and New York. Ohio in second place, well ahead of Indiana, regained the position it had in 1957. Pennsylvania was also the leading producer of beehive coke with a production of 713,150 tons about twice the 355,458 tons produced in 1958. The other three states producing beehive coke were Kentucky, Virginia and West Virginia who produced a total of 361,146 tons. Pennsylvania's portion of beehive was thus 66.3 per cent of the total. The marked increase in beehive production is due to the fact that competition from the chemical industry on products also furnished by coke ovens in some cases reduced the economic average which by-product coke has over beehive production.

Pennsylvania is also the leading producer for all types of coke with 14,468,996 tons or 25.9 per cent of the total production in the United States but slightly under the 26.7 per cent which was its share in 1958.

Surprisingly, United States is not the largest country for coke production and it trails the USSR by a small margin. Coke production in the USSR is reported at 58,860,000 tons compared with 55,863,000 tons in the United States. This continues the trend set in 1958 when the USSR produced 56,100,000 tons compared with 53,604,000 tons in the United States. Prior to that time the United States was ahead of anyone else. Next in the world order of coke producers is West Germany with 42,470,000 tons in 1959; China with 24,300,000 tons; United Kingdom with 19,045,000 tons; France with 14,550,000 tons; and Poland with 11,992,000 tons. Total world production in 1959 was 289,795,000 tons compared with 281,459,000 tons in 1958 and 293,913,000 tons in 1957, a year which reflected high steel production in the United States.

NUMBER AND CAPACITY OF OVENS

The total number of by-product ovens in existence at the end of 1959 totaled 15,993 compared with 16,244 at

TABLE V

Coal-Chemical Materials, Exclusive of Breeze, Produced at Coke-Oven Installations in the United States in 1959 (1)

Product	Produced	Sold			On hand Dec. 31
		Quantity	Value		
			Total	Average	
Tar, crude, gal	653,728,164	334,716,614 (2)	$ 42,633,118	$ 0.127	31,709,151
Tar derivatives:					
Sodium phenolate, gal	2,921,903	2,932,636	411,198	0.140	274,827
Crude chemical oil, gal	20,958,212	21,158,983	4,415,990	0.209	423,590
Pitch-of-tar: (3)					
Soft, net tons	526,905	22,597	608,477	26.927	7,702
Medium, net tons	48,730	20,610	695,528	33.747	6,426
Hard, net tons	142,070	40,642	1,407,650	34.635	3,768
Other tar derivatives (4)	...	...	10,737,764	...	...
Ammonia:					
Sulphate net tons (5)	612,738	655,446	$ 19,457,959	$ 29.687	98,950
Liquor (NH_3 content), net tons	14,709	14,061	922,901	65.636	1,051
Di- and mono-ammonium phosphate, net tons	46,904	48,588	5,365,958	110.438	5,364
Total	...	...	$ 25,746,818	...	...
Sulphate equivalent of all forms, net tons	716,703	758,575	...	...	...
NH_3 equivalent of all forms, net tons	184,765	195,561	...	...	...
Gas:					
Used under boilers, etc., M cu ft	804,600,058 (6)	62,957,231	$ 12,088,661	$ 0.192	...
Used in steel or allied plants, M cu ft		384,536,696	90,323,508	0.235	...
Distributed through city mains, M cu ft		34,809,978	14,782,947	0.425	...
Sold for industrial use, M cu ft		32,666,619	5,928,706	0.181	...
Total	804,600,058	514,970,524	$123,123,822	$ 0.239	...
Crude light oil, gal	213,036,193 (7)	19,514,987	2,992,927	0.153	3,863,545
Light oil derivatives:					
Benzene:					
Specification grades (all grades except motor)	119,831,005	123,489,823	$ 35,707,371	$ 0.289	5,715,635
Motor grade, gal	497,274	531,292	89,012	0.168	31,393
Toluene (all grades) gal	26,963,931	26,506,642	5,465,911	0.206	3,615,594
Xylene (all grades), gal	7,523,530	7,640,893	2,114,363	0.277	740,099
Solvent naphtha (crude and refined), gal	4,023,251	3,791,371	1,011,033	0.267	457,885
Other light oil derivatives, gal	3,149,762	1,877,374	255,722	0.136	166,588
Total	161,988,753	163,837,395	$ 44,643,412	$ 0.272	10,727,194
Intermediate light oil, gal	2,986,447	3,026,070	535,026	0.177	197,705
Value of all coal-chemical materials sold	...	...	$257,951,730	...	...

(1) Includes products of tar distillation conducted by coke-oven operators under same co-operate name.
(2) Includes 35,073,829 gal sold to affiliated companies for refining.
(3) Soft—water-softening point less than 110 F; medium—from 110 to 160 F; hard—over 160 F.
(4) Creosote oil, cresols, cresylic acid, naphthalene, phenol, pyridine, red oil, refined tar, road tar and tar paint.
(5) Includes ammonium thiocyanate.
(6) Includes gas used for heating ovens and gas wasted.
(7) 198,380,360 gal refined by coke-oven operators to make derived products shown.

the beginning of the year or a total drop of 251 ovens. Total annual coke capacity of by-product ovens at the end of the year was 81,447,700 tons. Beehive capacity was 4,368,800 tons. This is a drop of two per cent from the total capacity of 87,518,300 tons at the beginning of 1959. On this date by-product capacity had totaled 82,497,900 tons and beehive capacity had totaled 5,020,400 tons. The loss reflects the difference of about 1,000,000 tons in by-product capacity and 800,000 tons in beehive capacity.

The demands prior to the strike and the cutback in operation because of the strike interfered with programs for building new by-product ovens. The total number of beehive ovens in existence at the end of 1959 totaled 7448, a drop of 1234 from the 8682 in existence at the beginning of the year. Of these 6080 were in Pennsylvania and the remainder in the other three beehive states, Kentucky, Virginia and West Virginia. No ovens were reported for Utah which had some listed the year before.

Of the 15,993 by-product ovens, some 4133 were in Pennsylvania, next is Ohio with 2390, followed by Indiana with 2191, and followed again by Alabama with 1488. Both Pennsylvania and Ohio had fewer ovens than the year before, but Indiana and Alabama had the same numbers.

COAL CHARGED INTO OVENS

Coal charged into ovens in 1959 totaled 79,550,381 tons compared with 76,831,242 tons in 1958. Of these 77,722,907 tons, with a value of $768,075,654, was charged into by-product ovens and 1,827,474 tons, with a value of $11,152,140 was charged into beehive ovens. The coal charged into the by-product ovens thus had an average value of $9.88 a ton, and that into the beehive ovens $6.10 a ton, for an over-all average of $9.80 a ton. These figures compared with $9.89, $5.71 and $9.84 a ton in 1958. The higher proportion of beehive coke in

1959 brought the over-all cost average down 4¢ from the year before despite the fact that the beehive coke cost in 1959 was almost 40¢ higher than the year before. Also included in the over-all coal figures are 368,830 tons of anthracite valued at $3,860,098 or $10.47 a ton. The anthracite was 19¢ a ton higher than the year before.

It required slightly over 1.42 tons of coal to produce a ton of coke in 1959 compared with 1.43 tons in 1958, on an over-all basis. In the by-product plants it took 1.42 tons of coal to produce a ton of coke and it took 1.70 tons of coal to produce a ton of coke in the beehive ovens. This is essentially the same as the rates for the previous year. Thus the cost of the coal needed to make a ton of by-product coke in 1959 was $14.02 a ton, compared with $14.15 a ton in 1958. The cost of the coal to make a ton of beehive coke in 1959 was $10.38 a ton, compared with $9.69 a ton in 1958. Thus, in terms of coal the cost of by-product coke dropped in 1959, and beehive coke went up almost six per cent.

The leading states in mining coal for by-product ovens are in the order of their importance· West Virginia, Pennsylvania, Kentucky, Alabama and Virginia who produced 31,439,764, 21,224,188, 8,842,558, 5,912,034 and 4,330,263 tons, respectively; 71,748,807 tons or 92.4 per cent of the 77,722,907 tons which were mined for by-product ovens.

COKE USAGE AND DISTRIBUTION

The apparent consumption of all coke in the United States in 1959 was 54,667,533 tons, slightly higher than the 52,658,214 tons in 1958. This figure is about 1,200,000 tons under the 55,863,572 tons produced. Some 460,222 tons were exported in 1959, and 123,255 tons were imported. The remainder went to increasing coke stocks which totaled 4,682,436 tons.

As usual by far the largest percentage of the coke was used in the blast furnaces, and this user took 49,377,383 plus 39,831 tons which were exported for blast furnace use, or 88.8 per cent of the total production of 55,863,572 tons. This is exactly the same proportion and slightly under the 47,597,825 tons used by blast furnaces in 1958. The coke needed to make a net ton of pig iron and ferro-alloys in 1959 was 1587.6 lb compared with 1613.4 lb in 1958, a drop of about 26 lb and continuing the steady reduction taking place over the past few years. Analyzing the actual rate it took 2261.5 lb of coking coal to make a ton of pig iron in 1959, compared with 2311.5 lb in 1958.

Some 2,689,848 tons of coke were delivered or exported to foundries in 1959 compared with 2,145,018 tons for the same period in 1958. Foundry use was about 4.86 per cent of the total.

Coke shipped to producer- and water-gas plants in 1959 totaled 227,666 tons; to other industrial plants, 2,214,532 tons; for residential heating 473,488 tons. The comparable figures for 1958 were 624,791 tons; 1,966,562 tons and, for residential heating, 603,876 tons.

Since coke is used primarily for steelmaking purposes, most of it is produced in plants near the using operation in order to reduce transportation costs and also to make use of the by-product fuels in other operations.

The largest user of coke was Pennsylvania in 1959 with a total of 13,333,761 tons, compared with 13,385,210 tons in 1958. The second largest user was Ohio with 9,951,062 tons in 1959, compared with 8,416,038 tons in 1958. Following these two states were Indiana with 5,401,326 tons, Illinois with 4,471,358 tons, Alabama with 3,780,990 tons, Michigan with 3,730,105 tons and New York with 3,282,193 tons.

STOCKS OF COKE AND COKING COAL

Coke stocks increased appreciably during the year, going up 859,072 tons to 4,682,436 tons at the end of 1959. The stock at the beginning of the year was 3,823,364 tons.

GROSS VALUE AND YIELDS OF BY-PRODUCTS

The total gross value of by-products sold in 1959 totaled $257,951,730 which is slightly under the $266,713,569 sold in 1958. Some of the by-products made were also used by the producers so that the total value of the coke chemical materials which were sold and used totaled $288,153,722 compared with $299,878,695 in 1958. The gross value of the by-products was therefore about 29.1 per cent of the $992,084,812 the value of the coke, exclusive of breeze, purchased at the by-product ovens. An average of $23.65 per ton of by-product coke produced was realized from the coke, coke breeze and coke chemical materials compared with $24.44 in 1958. This includes $17.88 for the coke, 47¢ for the breeze and $5.30 for the coke chemical materials. The coal cost per ton of by-product coke was $14.02 in 1959 compared with $14.15 a ton in 1958. The coal cost per ton of beehive coke was $10.38 in 1959, compared with $9.69 in 1958.

The yield, in terms of dollars, for the primary coke by-products in 1959 was less than in 1958. The physical yields in 1959, compared with 1958, were also somewhat lower as tar decreased from 8.83 in 1958 to 8.41 gal per ton of coal; ammonium sulphate decreased from 19.86 lb to 18.70 lb in 1959; crude light oil decreased from 2.95 to 2.81 gal per ton in 1959; and surplus gas used or sold moved downwards slightly from 6.62 to 6.60 M cu ft per ton of coal.

NATURAL GAS

Marketed production of natural gas in the United States in 1959 totaled 12,046,115,000,000 cu ft, an increase of 9 per cent over the 1958 total of 11,030,248,000,000 cu ft. Texas was easily the leading producing state, yielding 5,718,993,000,000 cu ft; and following in second position was Louisiana with 2,670,271,000,000 cu ft.

Consumption of natural gas in 1959 totaled 11,819,638,000,000 cu ft, compared with 10,760,648,000,000 in 1958. Distribution was as follows: industrial, 5,979,916,000,000 cu ft; residential, 2,912,601,000,000; field 1,737,402,000,000; commercial 975,107,000,000; and carbon black, 214,612,000,000 cu ft. There was an increase in storage of 118,742,000,000 cu ft stored in 1959.

Marketed production in 1959 increased in each of the distributions as follows: industrial, 12 per cent; residential, 7 per cent field, 8 per cent; commercial, 12 per cent; carbon black, 2 per cent for an over-all average increase of 10 per cent over 1958. The average value at point of consumption in 1959 was 47.7¢, compared with 46.2¢ in 1958. ▲

Wear in work and backup rolls of strip mills changes load distribution along the rolls to give very high local stress values which may lead to spalling and other high contact stress failures . . . . wear is also an important factor in gage across width of strip . . . . without radial deformation holding gage would be very much more difficult.

Effect of Roll Wear on Spalling

by J. D. KELLER,
Consulting Engineer,
Associated Engineers,
Pittsburgh, Pa.

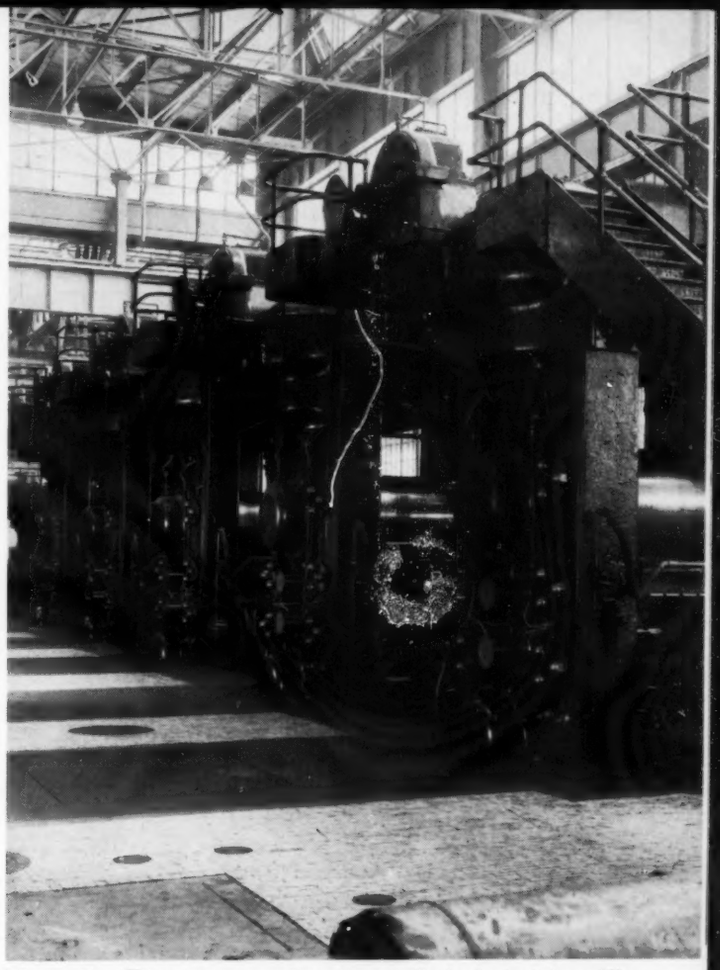
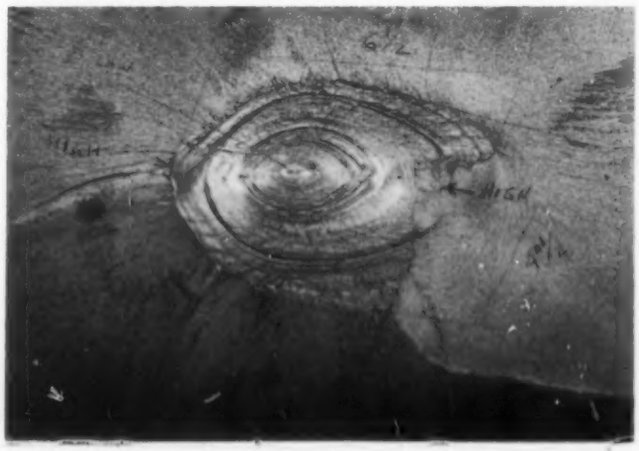


Figure 1 — The severe service given rolls in hot strip mills often leads to spalls.

THE spalling or cracking-out of pieces, large or small, from the surface of the work rolls and the backup rolls in hot strip mills is a matter of major concern to the owners and operators of these mills. Spalling of the work rolls can cause defects in the strip surface which make the product unacceptable; can cause trouble in the coiler due to "ridge rolling"; and may even result in breakage of the roll. Spalling of the backup rolls interferes with their proper function of supporting the work rolls; it can cause marking of the work roll surface (which marking may be transferred to the strip), as well as repeated spalling of the work rolls; and again it may result in roll breakage.

Spalling of the backup rolls is also very objectionable, because these large rolls are expensive and because removing them from the mill for redressing is a major operation. Figure 1 is a closeup view of the rolls in a stand in the finishing train of a tandem hot-strip mill, spalls in a backup roll and a work roll can be seen in Figure 2.

Figure 2 — This spall occurred in a 56-in., 3-stand cold tandem mill. Roll was forged steel work roll and had no history of cobble.



Several years ago the Joint Roll Research Committee (Association of Iron and Steel Engineers—Roll Manufacturers Institute) began an extensive program which is still in progress, to determine the causes of roll spalling. It soon became evident that spalling might be greatly accelerated by nonuniform wear of the rolls, which would cause a concentration of load at some places along the length of contact of the work on the backup rolls, and producing contact stresses which could exceed the strength of the roll materials.

It was therefore necessary as a first step, to determine by actual measurement the amount of wear and its distribution along the roll length, in both work rolls

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The yield, in terms of dollars, for the primary coke by-products in 1959 was less than in 1958. The physical yields in 1959, compared with 1958, were also somewhat lower as tar decreased from 8.83 in 1958 to 8.41 gal per ton of coal; ammonium sulphate decreased from 19.86 lb to 18.70 lb in 1959; crude light oil decreased from 2.95 to 2.81 gal per ton in 1959; and surplus gas used or sold moved downwards slightly from 6.62 to 6.60 M cu ft per ton of coal.

NATURAL GAS

Marketed production of natural gas in the United States in 1959 totaled 12,046,115,000,000 cu ft, an increase of 9 per cent over the 1958 total of 11,030,248,000,000 cu ft. Texas was easily the leading producing state, yielding 5,718,993,000,000 cu ft; and following in second position was Louisiana with 2,670,271,000,000 cu ft.

Consumption of natural gas in 1959 totaled 11,819,638,000,000 cu ft, compared with 10,760,648,000,000 in 1958. Distribution was as follows: industrial, 5,979,916,000,000 cu ft; residential, 2,912,601,000,000; field 1,737,402,000,000; commercial 975,107,000,000; and carbon black, 214,612,000,000 cu ft. There was an increase in storage of 118,742,000,000 cu ft stored in 1959.

Marketed production in 1959 increased in each of the distributions as follows: industrial, 12 per cent; residential, 7 per cent field, 8 per cent; commercial, 12 per cent; carbon black, 2 per cent for an over-all average increase of 10 per cent over 1958. The average value at point of consumption in 1959 was 47.7¢, compared with 46.2¢ in 1958. ▲

Wear in work and backup rolls of strip mills changes load distribution along the rolls to give very high local stress values which may lead to spalling and other high contact stress failures . . . . wear is also an important factor in gage across width of strip . . . . without radial deformation holding gage would be very much more difficult.

Effect of Roll Wear on Spalling

by J. D. KELLER,
Consulting Engineer,
Associated Engineers,
Pittsburgh, Pa.

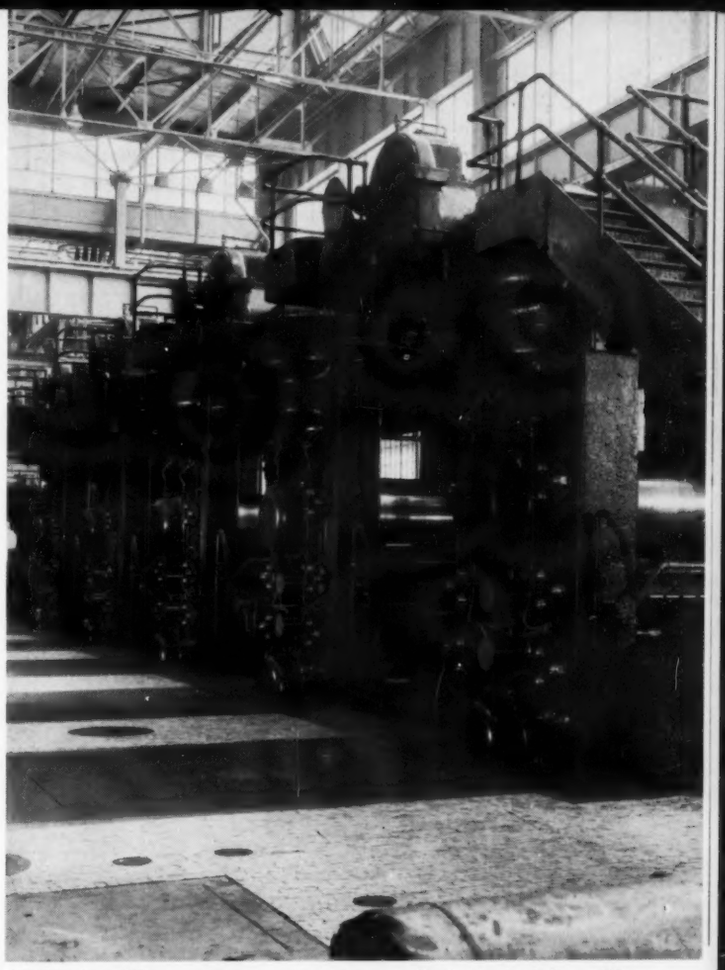
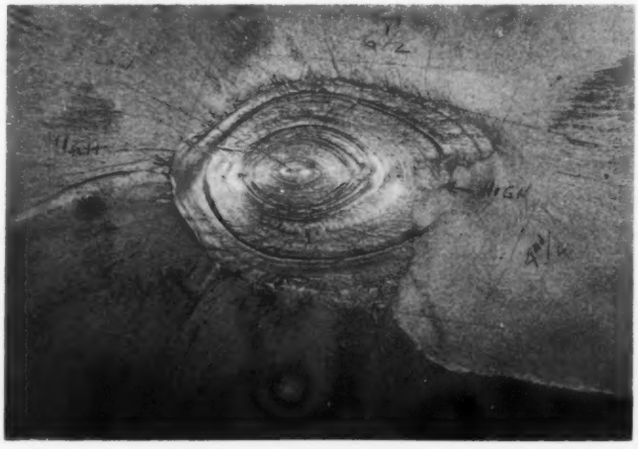


Figure 1 — The severe service given rolls in hot strip mills often leads to spalls.

THE spalling or cracking-out of pieces, large or small, from the surface of the work rolls and the backup rolls in hot strip mills is a matter of major concern to the owners and operators of these mills. Spalling of the work rolls can cause defects in the strip surface which make the product unacceptable; can cause trouble in the coiler due to "ridge rolling"; and may even result in breakage of the roll. Spalling of the backup rolls interferes with their proper function of supporting the work rolls; it can cause marking of the work roll surface (which marking may be transferred to the strip), as well as repeated spalling of the work rolls; and again it may result in roll breakage.

Figure 2 — This spall occurred in a 56-in., 3-stand cold tandem mill. Roll was forged steel work roll and had no history of cobble.



Spalling of the backup rolls is also very objectionable, because these large rolls are expensive and because removing them from the mill for redressing is a major operation. Figure 1 is a closeup view of the rolls in a stand in the finishing train of a tandem hot-strip mill, spalls in a backup roll and a work roll can be seen in Figure 2.

Several years ago the Joint Roll Research Committee (Association of Iron and Steel Engineers—Roll Manufacturers Institute) began an extensive program which is still in progress, to determine the causes of roll spalling. It soon became evident that spalling might be greatly accelerated by nonuniform wear of the rolls, which would cause a concentration of load at some places along the length of contact of the work on the backup rolls, and producing contact stresses which could exceed the strength of the roll materials.

It was therefore necessary as a first step, to determine by actual measurement the amount of wear and its distribution along the roll length, in both work rolls

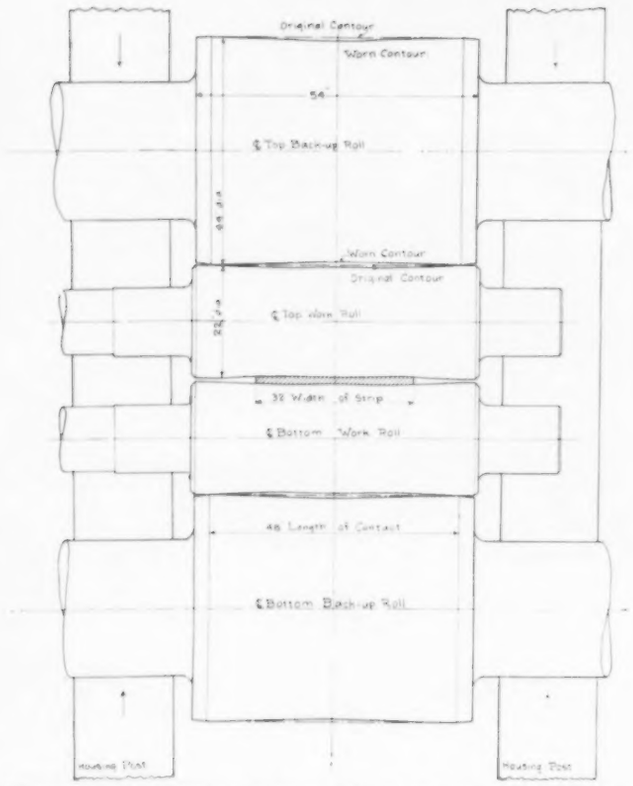


Figure 3 — Schematic shows roll setup to which design example is applied. Gaps and wear shown are not to scale.

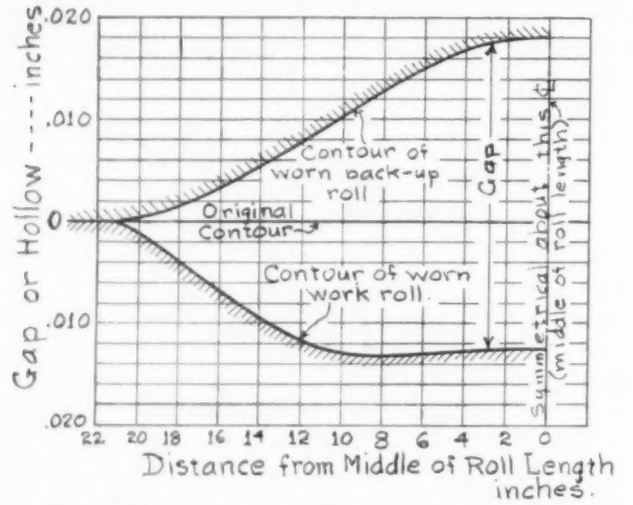


Figure 4 — Wear on mill rolls here shown was measured in AISE-RMI roll research program.

and backup rolls, as well as the changes of contour due to thermal expansion. This work was started and measurements were made on three different hot strip mills, by Dr. C. E. Peck, then at Carnegie Institute of Technology. Later the work was continued by Dr. George Sachs and J. V. Latorre of Syracuse University Research Institute (SURI), with measurements on additional hot strip mills and on one cold strip mill.

Such measurements are extremely difficult to make with accuracy. They must not interfere with the regular operation or reduce the output of the mill. Ordinarily the dimensions can be measured only after the rolls have been removed from the mill for redressing, and not always at a set time after removal, which means that the rolls have cooled to varying degrees (and probably contracting on cooling) when their contours are measured. It is therefore necessary also to measure the temperatures of the rolls at various points along their length, while they are in operation in the mill and make correction for the thermal expansion.

Satisfactory means and techniques were finally worked out, and measurements of roll contours or wear patterns have now been obtained for representative mills.

While this work was being done, the question arose on how were the measurements of worn-roll contours when completed to be utilized for determining the distribution of load along the roll length, and the stresses produced thereby.

The author in 1958 developed for the committee a mathematical method. In it, the half-length of the contact of the work roll on the backup roll was divided into six equal sections, and six simultaneous equations were written, including the bending and shear deflections and the radial deformations of both rolls. The equations, solved "long hand" in some cases and by an electronic computer in others, provided most interesting information.

Not satisfied with this, the author in November, 1959, developed another, combination graphical and numerical method, which it is one of the purposes of this article briefly to describe.

In Figure 3 are shown diagrammatically to scale the dimensions of the rolls to which the calculations will apply, but with the worn roll contour greatly exaggerated.

In the finishing stands, the work rolls are usually double-poured alloy cast iron rolls, having a very hard, chilled white iron shell which initially is about 1½ in. thick, with surface hardness about 80 Scleroscope (or about 60 Rockwell C). The backup rolls are usually cast steel, slightly softer than the work rolls, their surface hardness being about 40 Rockwell C. In spite of their high hardness, the work rolls are worn so rapidly by the hot strip that they must be taken out of the mill for redressing about every eight hours, or sometimes even more frequently. The backup rolls, which do not normally contact the hot strip, wear much less rapidly, but after about two weeks they too have worn about as much as the work rolls did in eight hours, and then the backup rolls also must be taken out for redressing.

In Figure 4 are shown wear contours of the work roll and of the backup roll, as measured by Dr. Peck in a 24 and 44 x 54 in. hot mill and used in the present calculation. The trough-shaped contour is typical for work rolls, but often the backup roll contour, according to later measurements, instead of being parabolic is also trough shaped. The contours shown in Figure 4 will be used in the present calculation.

With a "gap" existing between the rolls, due to wear, as shown in Figure 4, if the rolls were perfectly rigid the work roll would be supported by the backup roll over a length of only about three in. near each end, and the pressure there would obviously be intolerably high. The rolls actually are not entirely rigid, but can deform elastically and thus relieve the stress concentration to some extent. The elastic yielding comprises bending and shear deflections and radial deformations.

Considering the effect of the various forces separately, and assuming temporarily that the rolls are held

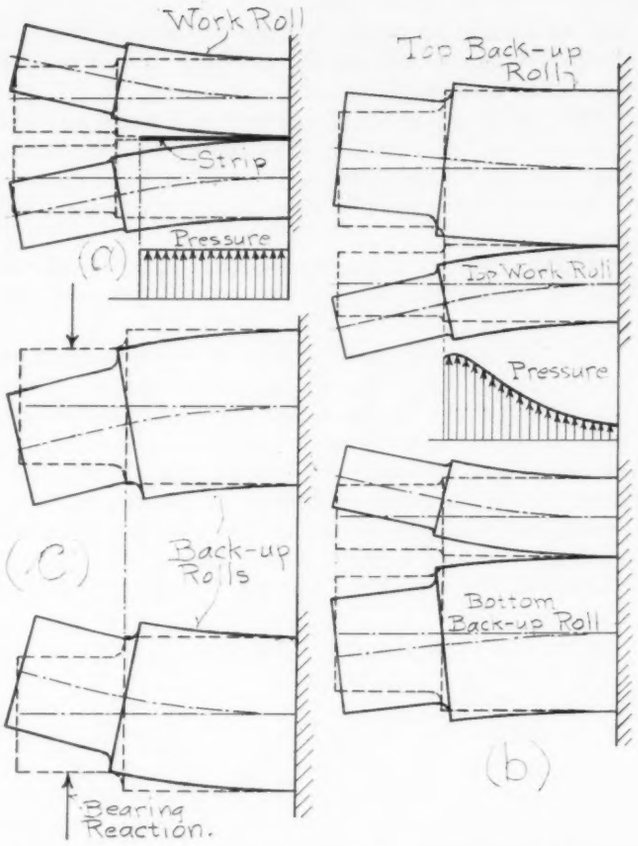


Figure 5 — Exaggerated diagrams show bending deflections of rolls: (a) work roll deflection under pressure of strip; (b) work roll deflection under pressure of backup rolls, and backup rolls under pressure of work rolls; and (c) backup rolls under bearing reaction loads.

at the middle of their length, the work rolls (top and bottom) are bent away from each other by the pressure exerted on them by the hot strip, as shown exaggeratedly in Figure 5a. The work rolls are bent toward each other and the backup rolls are bent away from the work rolls, as in Figure 5b, by their mutually-exerted pressure, the shape of which pressure curve is unknown and is to be determined. Finally, the backup rolls are bent toward the work rolls and toward each other by the bearing reactions, as in Figure 5c. The purpose of the calculation is to determine the distribution, over the contact length, of the work-roll-on-back-up-roll pressure in Figure 5b.

(In referring to Figure 5, in order to avoid confusion it should be kept in mind that the zero point for deflections is, for the present purpose only, considered to be the middle of the roll length. In other words, the deflections shown in the various parts of Figure 5 are the deflections *relative* to the mid-point of each roll.)

On the assumption that the distribution of the pressure of the strip on the work rolls is practically uniform along the strip width, the bending and shear deflections of the work roll for Figure 5a can easily be calculated by well known equations, as can those of the backup roll for Figure 5c due to the bearing reaction.

The bending and shear deflections are outweighed by another factor, the radial compression of the rolls. The extreme importance of this radial deformation, in large rolls, has by no means been recognized as it should be. Except for the occurrence of radial deformation, satisfactory rolling of strip between worn rolls would be impossible.

The nature of the loading producing radial deformation is shown in Figure 6.

Using the best information now available, the total radial deformation as calculated by Föppl's equations, (1)* from the axis of the work roll to the axis of the backup roll, is shown by the solid line in Figure 7 as related to the unit load. The line (being a logarithmic curve according to Föppl) is somewhat curved; it can be approximated by the broken straight line shown, with an error of less than one per cent over the range of loads actually encountered. However, with the new calculation method there is no need to introduce such an approximation.

As to the bending deformation caused by the pressure of the work roll and backup roll on each other, for any

* Numbers in parentheses refer to Bibliography at end of paper.

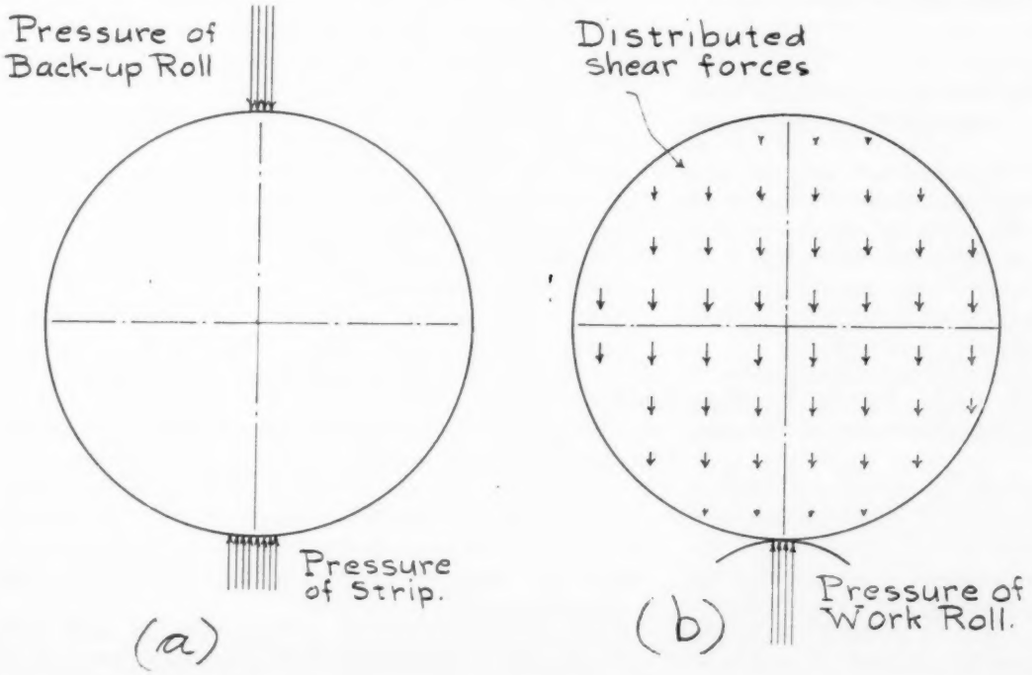


Figure 6 — Forces and reactions in (a) cause radial deformation on work roll and in (b) cause radial deformation on backup roll.

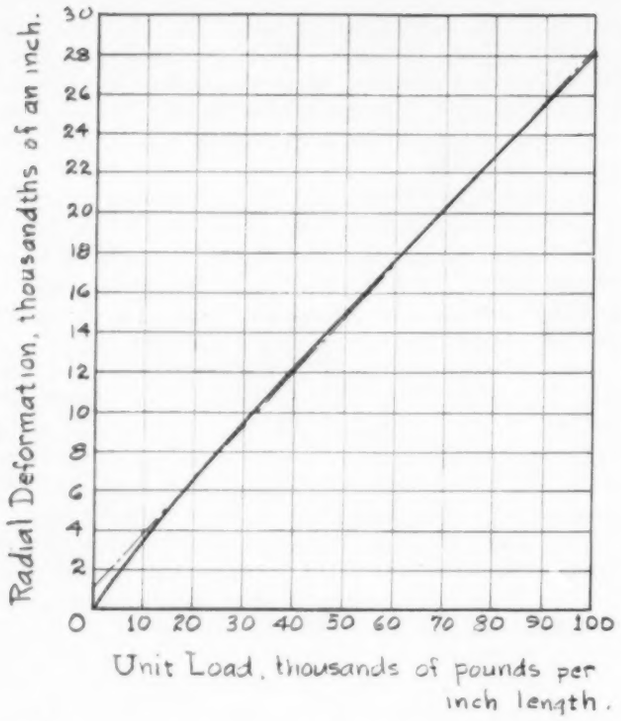


Figure 7 — Curve gives radial deformation from axis of 24-in. diam double poured work roll to axis of 44-in. diam cast steel backup roll for various loads.

pressure distribution this may best be figured by the graphical method originated by O. Mohr (the discoverer of Mohr's Circle of stress). This method was first published in the United States by Professor W. Trinks (2) in 1902, and is also explained at length in Goodman's "Mechanics." For this deformation the two rolls can be figured as a unit. The shear deformation can also be obtained by the graphical method, but is simpler to calculate by numerical summation.

For the benefit of those who may not have the mentioned references readily available, the graphical method of calculating bending deflections is briefly in the Appendix.

NEW METHOD FOR CALCULATING PRESSURE DISTRIBUTION

The new method is based on the fact that the two primary factors determining the load-distribution along the length of contact of the work roll on the backup roll, are the initial gap between the rolls (Figure 4) and the radial deformation of the rolls (Figure 7); the bending and shear deflections of the rolls in strip mills are secondary, though still important.

The method involves a rapidly converging series of approximations, somewhat similar to the Rayleigh-Ritz method of determining the deflections of vibrating beams.

The starting point is the gap, or open space between work roll and backup roll when in contact under zero pressure, as shown in Figure 4. For the first trial, the roll centerlines or axes are assumed to be moved closer together, parallel to each other and without bending or shear deflection, until the gap is partially or totally closed and the total load reaches any set value desired. The unit load (lbs per in. length) for each decrease of distance between roll centers is found from Figure 7 for all points along the length.

The half-length of contact of work roll on backup roll is divided into a number of equal spaces, preferably not less than six and for accuracy 10 or 12, and the summation of the loads on all these spaces gives the total load.

The unit force is naturally greatest where the initial gap was least—usually near the ends of the roll contact.

The load distribution thus obtained (by consideration of the closing of the gap by radial deformation alone) is used as the first trial load, and the bending deflections of the rolls due to this load distribution are found either numerically by considering the load on each of the equal spaces as a concentrated load at its middle, or—preferably, and at a great saving of time—by the graphical method, described in the Appendix as shown in Figure 8. The shear deflections are also calculated for this trial load.

Both the work roll and backup roll centers deflect away from the strip pass line. Therefore the deflection of the work roll tends to close the gap near the middle of the roll length, and the deflection of the backup roll tends to open this gap and they work against each other. The total backup roll deflection (bending plus shear) must therefore be subtracted from the total work roll deflection, the net is deducted from the initial gap to give the deflection-modified gap, at all points along the half-length, for the second trial.

The loads corresponding to the modified gap are found from Figure 7, and if necessary the deflected roll centerlines are then moved slightly toward or away from each other as may be required to give the same *total* load for the second trial.

For the new load distribution thus obtained, the bending deflection is recalculated by the graphical method as before, and a new or second deflection-modified gap is obtained, for all points along the length. This is found to be intermediate between Trial No. 1 and the initial gap.

The results of these successive trials oscillate about the true value, first too high and then too low, but converging toward the true value. (See Figure 9).

A mathematical "trick" is now used in order to produce quicker convergence toward the final, true result. If, for example, at a given point in the length, the difference between the result of Trial No. 2 and the result of Trial No. 1 is found to be, say 35 per cent of the difference (call this dx) between Trial No. 1 and the initial gap (call this x_0), then the convergence factor is 0.35, and since the values from successive trials are oscillating about the true value (being alternately above it and below it) but converging toward it, we have:

Final $\underline{x} = x_0 - dx + 0.35\,dx - (0.35)^2\,dx + (0.35)^3\,dx - (0.35)^4\,dx + \ldots\ldots$ or $\underline{x} = x_0 - 0.2594dx$

Since the convergence factor varies along the length, this calculation should be made for each of the sections into which the length is divided, and from it the modified gap to be used for the third trial should be determined for each point.

(There will probably be a slight upward or downward revision of this, equal at all points, required to adjust

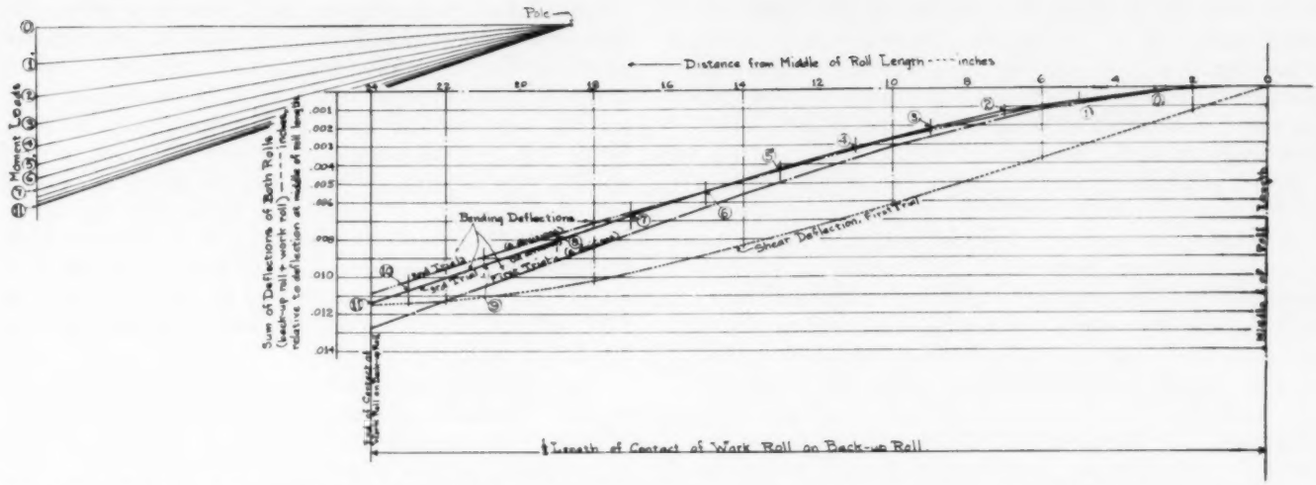

Pole
Moment Loads
Distance from Middle of Roll Length ---- inches
Bending Deflections
Shear Deflection, First Trial
Length of Contact of Work Roll on Back-up Roll

Figure 8 — Curves give bending deflection of rolls determined by Mohr's graphical method. Shear deflection is also given.

the total load to the initially chosen value.)

With this final modified load distribution, the graphical deflection determination is completed for the third time, and the corresponding modified gap and corresponding load distribution completed. The load distribution is shown in Figure 9.

In the example which was worked by this new method, for a total load of 1,318,420 lb which is nearly the least load that will close the gap of Figure 4 at the middle of the roll length, the agreement of the result of the third trial with both the starting load for the third trial (obtained by the convergence calculation from the initial load and the results of the first and second trials), and with the result previously calculated by the simultaneous-equation method, was gratifyingly close. As shown in Table I, the agreement was almost exact near the ends, where the loads are highest, and even near the middle where the loads were lowest the agreement was within 2.5 per cent.

At this point it should be emphasized that the use of the graphical method of determining bending deflections is by no means essential to the new method of determining load distribution. Numerical calculation methods may be used instead, for finding the bending deflections, and when a high speed electronic computer is available such methods may be preferable. But the heart of the new method of determining the load distribution along the roll length is the use of successive converging approximations, starting with the roll "gap" as a basis, as explained in the preceding.

RESULTS OF THE UNEVEN DISTRIBUTION OF LOAD

When the rolls have worn to such an extent as indicated in Figure 4, the pressure or load is very unevenly distributed over the length of contact of the work rolls on the backup rolls. In the case for which the calculation was made, it can be seen from Table I and from the solid-line curve in Figure 9 that the load in lb per in. length near the middle of the roll length is only about one-third of the average load, while near the ends it reaches a peak of 185 per cent of the average.

Calculation of the stresses in the rolls at the contact of work rolls with backup rolls, using the Hertz theory of contact of elastic bodies, shows that near the ends, the unit load of about 101,000 lb per in. length (see Table I) would produce a compressive stress at the contact surface of 242,000 psi. Since this is a compressive stress and since lateral restraining forces are exerted on the highest-stressed parts by the adjacent material of the roll, the roll material may be able to sustain this stress without harm.

In both the backup roll and the work roll, *shearing* stresses are also produced, which reach a maximum of about 74,000 psi at a depth of about 0.21 in. below the surface. This is a repeated but not an alternating stress, passing through the range from zero to 74,000 psi at every time of contact; that is, once every revolution. There are also, however, alternating or reversed shear stresses, at a depth of about 0.13 in. below the surface, ranging from plus 63,000 to minus 63,000 psi at every revolution.

According to a refinement of Hertz' equations by D. Jortner (3) and also by T. T. Loo, (4) these stresses may actually be increased as much as 10 per cent due to the effect of curvature.

It is believed that these repeated or alternating shear stresses produce fatigue cracks in the roll ma-

TABLE I

Unit Loads (Lb per In. Length) Calculated in Successive Trials, for total load of 1,318,420 lb on half-length

Distance from middle of roll length, in.	24	22	18	14	10	6	2
First trial (radial deformation only, no bending deflection)	118,590	118,590	98,590	61,490	30,790	14,140	5,990
Second trial	94,075	96,595	85,345	58,875	37,375	28,190	23,225
Start of third trial	99,870	102,700	88,440	59,400	36,320	25,090	17,680
Final result of third trial	99,870	101,130	88,400	59,600	36,150	25,110	19,200
Result previously obtained by simultaneous equation method	100,000	101,430	87,395	59,134	36,528	25,462	19,656

terial near the surface; the cracks are very effective stress-raisers in the rather brittle material, possibly producing a five-to-ten-fold magnification of stress, causing the cracks to penetrate gradually inward into the roll and outward to the surface. After a time, pieces then spall out of the roll surface.

It is by no means certain, however, that the cracks do start at the rather small depth below the surface which would correspond to the maximum shear stresses; or even that they start below the surface at all. The matter of spalling is of such importance that large numbers of spalls have been observed, studied, photographed and even classified as to type, and yet there is no agreement as to where they start. Some observers are reasonably sure that the cracks start at the roll surface, while others equally competent think they start below the surface, and often at considerable depth. The probability seems to be that both kinds occur.

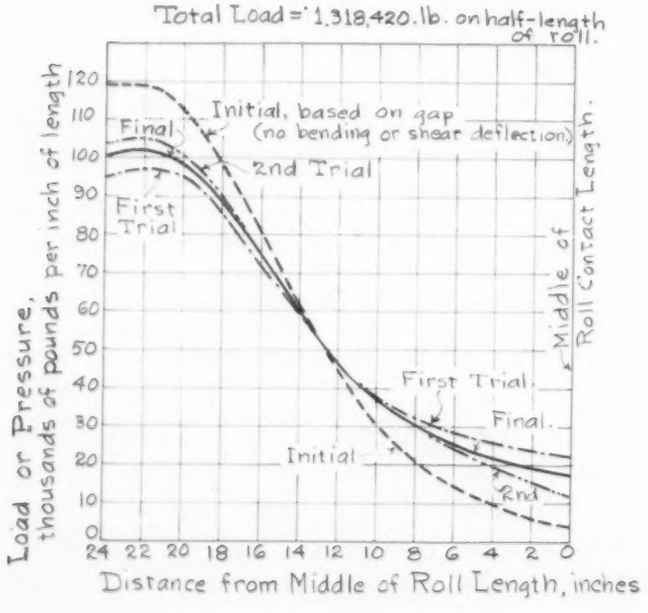
Tangential forces due to friction may produce increased stresses at the surface. Also, there are the possibilities of corrosion fatigue cracking by alternate wetting and drying, of a wedging action of fluid penetrating into microscopic surface cracks, of effects due to chemical or mechanical action of the cooling water or of steam, of temperature stresses caused by skidding, and of plastic-flow conditions in the rolls near the place of load application.

However, including any or all of these, the seriousness or the probability of trouble will be increased by high mechanical stresses, and that is why it is so important to determine accurately the load distribution along the roll length.

EFFECT OF LOAD REDUCTION

The question will be asked, if the strength of the roll material is not too greatly exceeded by the stresses resulting from the loads shown in Figure 9, would it not be desirable to save the rolls by reducing the total load on the mill to a somewhat lower but not greatly lower amount, since the stresses would be expected to be proportional to the load?

Figure 9 — Load distribution along roll was calculated by method of successive converging approximations.



Unfortunately it does not work that way, when the rolls are worn. This can be seen from a comparative example. For this same mill, a safe and usual load is about 37,500 lb per in. width of strip, or a total force per roll equal to 1,200,000 lb for 32-in.-wide strip, or 600,000 lb per roll-neck. This is only 45½ per cent of the load for which the distribution is given in Table I and in Figure 9. Yet calculation shows that the maximum unit load, occurring near the ends of the rolls, is then 69,000 lb per in. length, or 68 per cent as much as for the larger load. The maximum Hertz shearing stress is 60,800 psi, or 82 per cent as high as it was with 2.2 times the load.

The reason for the surprising smallness of the decrease of unit force and stress, is that under the lighter load the wear-gap does not close completely near the middle of the roll length. For a distance of about 18 in. it remains open, which means that the load is then carried on only 30 in. of contact length instead of 48 in.

EXCEPTIONS AND OBJECTIONS

In the work of the joint committee, questions arose and objections were made to some of the data, methods and assumptions. These may well be discussed briefly here.

The sole basis available on which the magnitude of the radial deformation of rolls can be calculated is the mathematical derivation of Föppl, (1) which in turn was based on Hertz' theory of elastic contact. Both Hertz and Föppl neglected the effect of the surface curvature at the place of contact. Recently, D. Jortner (3) and T. T. Loo (4) have studied, independently, the effect of this curvature, and found that it may increase the stress in some cases by as much as 10 per cent, but has less effect on the total radial deformation. A further-refined calculation was made very recently by Zorowski and Weinstein (5).

Strange as it seems, no reliable actual measurements of the radial deformation of either spheres or cylinders have been made, or at least no report of such tests has been found.

For the work roll, which is loaded approximately at opposite ends of a diameter as shown in Figure 6a, Föppl's equations with Jortner's and Loo's correction should apply directly. They, however, assume constant modulus of elasticity throughout the roll cross section, whereas actually in double-poured iron rolls E ranges from 23,000,000 to almost 30,000,000 psi in the white iron shell, but is only about 15,000,000 psi (or even lower) in the gray iron core which comprises about 85 per cent of the diameter. At present, the correction can be made only by estimate, but work is in progress at SURI to determine by actual measurement in a 300,000 lb testing machine the radial deformation of both double-poured iron rolls and steel rolls.

The steel backup roll is practically homogeneous throughout and accounts for only about ⅜ of the total radial deformation. On the backup roll, however, the system of loading does not comprise a force at one end of a diameter balanced by a reaction at the other end of the diameter as in the work roll. Instead, the reaction in the backup roll is a system of shear forces distributed over the cross-section of the roll, as in Figure 6b. For this condition, no accurate calculation

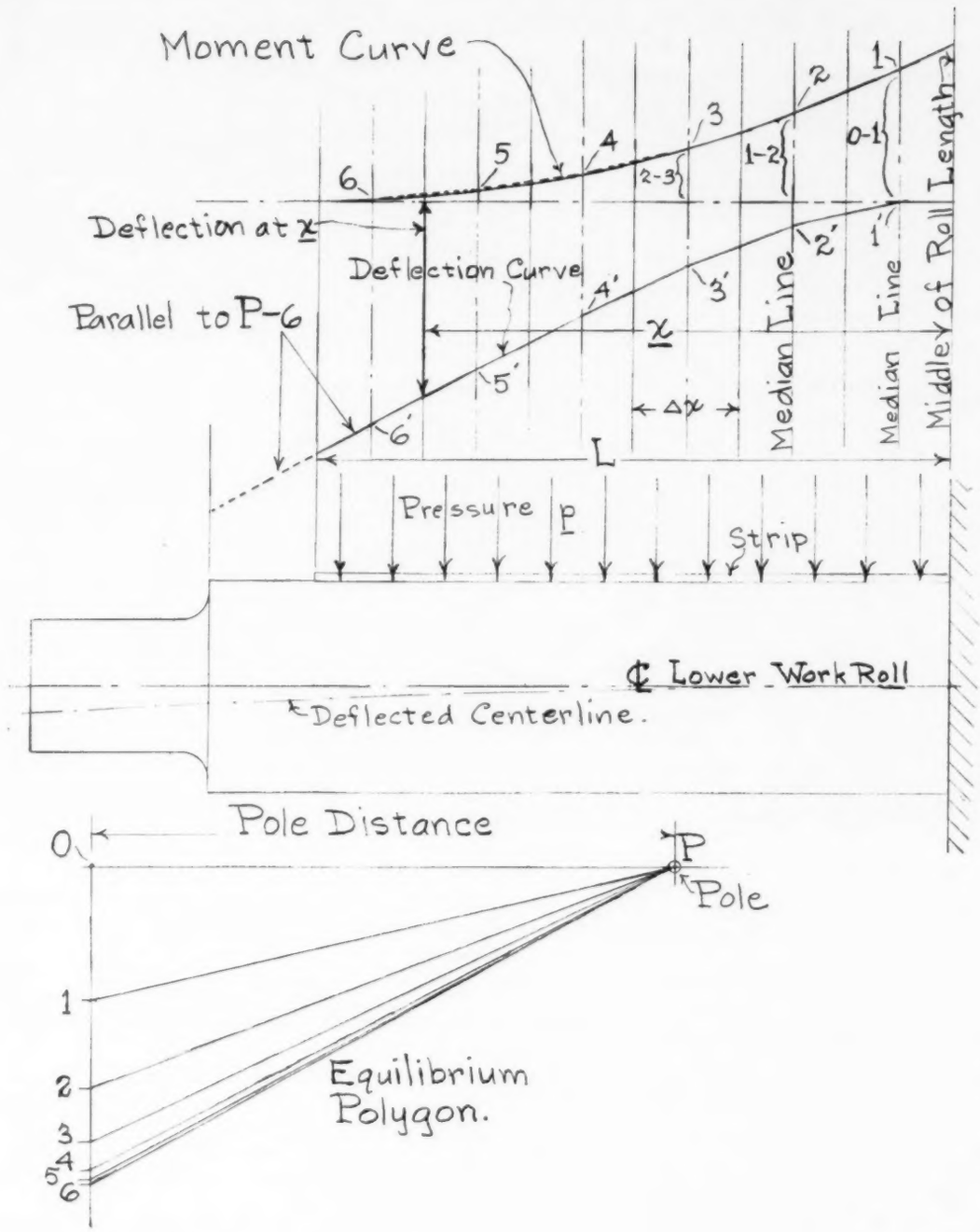


Figure 10 — The half-length of the roll is considered as a cantilever and uniformly loaded by the pressure of the strip.

for the radial deformation is known. The nearest thing to it is Mitchell's case of the "heavy disk supported by a plane," but in this the forces (due to gravity) are uniformly distributed over the cross-section, whereas the shear forces in the case of bending are much greater near a horizontal plane through the axis than near the top and bottom. At present the best that can be done is to take the radial deformation the same as for diametrically opposite loads, but to realize that this is probably somewhat too large. A mathematical investigation of the radial deformation of backup rolls is being started by Professors Zorowski and Weinstein at Carnegie Institute of Technology and by Professor Tong at SURI.

Another possible modifying factor is restraint of the radial deformation of any "slice" or portion of the length of the roll by the resistance (transmitted by shear) of adjacent, less highly stressed slices. This, however, is probably negligible in magnitude because there is no *abrupt* change of load distribution. The load-vs-length curve would have to be very steep, for this factor to become important.

A questionable item is the constant to be used in calculating the shear deflection of the rolls; one authority on elastic deformation, namely Timoshenko, gives the value of 4/3 for this constant, while another, namely Seeley, gives 10/9. This discrepancy is by no means unimportant, since in these short, comparatively thick rolls, the shear deflection may be as much or even somewhat more than the bending deflection. See Figure 8. The truth is that the theoreticians have concentrated their attention on bending deflection and have relegated shear deflection to the condition of a neglected step-child.

With the bending deflection there is the question of the large depth of the beam (or roll) in proportion to its length. One of the assumptions on which the theory of elastic bending is based, is that the depth of the beam

is quite small compared to its length. In strip mill backup rolls, the depth (or diameter) may be as much as 50 per cent of the length in which bending occurs. Only one investigator, namely Filon (6), seems to have studied the modification required in deep beams, and that for only one special case. A thorough investigation of both the bending and the shear deflection of deep beams is needed. Now that electronic computers are available it should not be too difficult.

Fortunately, both shear and bending deflection of the rolls are in most cases much less important than the radial compressive deformation, concerning which there will be accurate information from the investigations now in progress.

The author confidently expects that "when all the returns are in," and all refinements made, the final results for the maximum stresses will be found to differ by not more than about 5 per cent from those stated in this article. This is a personal opinion and not necessarily that of the committee.

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APPENDIX

The deflection of the work roll by the pressure of the strip (if it were not supported by the backup roll) as in Figure 5a, will be used as an example. For the present purpose, the half-length of the roll will be considered as a cantilever built in at the mid-point and uniformly loaded by the pressure of the strip over the length L in Figure 10. The pressure is p lb per in. of length. If x is any distance from the fixed end, the moment at x is $p(L-x)^2/2$. This moment as it varies over the length is laid out at the top of Figure 10, and is a parabolic curve in this example.

The length L is now divided into a number of equal sections, six in this example, and a median line is drawn for each space, (vertical dot-dash lines in Figure 10). The moment curve is approximated by straight lines across each section (dotted lines). The corresponding moment at the median line nearest the fixed end is measured, and is laid off to a suitable scale on the vertical line of the lower sketch in Figure 10 measuring downward from the horizontal line through point O. Thus the vertical distance O–1 in the lower sketch is either equal to or a fixed fraction of distance 0–1 in the upper sketch.

Then the height of the moment line in the upper sketch at the next median line to the left (or the same fixed fraction of this height) is laid out as vertical distance 1–2 in the lower sketch; and so on, until the moments for all of the sections have been laid out.

A "pole distance" is now calculated and measured off on the horizontal line at the top of the lower sketch. It is

$$\text{Pole Distance} = (\text{S.D.})\ \frac{EI}{m\ \Delta x\ n^2} \quad \ldots\ldots (1)$$

where (S.D.) = scale of deflections, in. per in. = actual deflection/deflection on layout

M = scale of moments, in.-lb per in. on vertical line in lower sketch

Δx = width of each strip into which the moment load is divided, in.

n = scale of length, in. per in. = length on layout/actual length

E = modulus of elasticity of roll material, psi

I = moment of inertia of cross-section of roll, in.^{4}

(In cases where the roll diameter varies along the length, the moment curve in upper sketch is modified in inverse ratio to the moment of inertia at each of the different diameters, as explained in Prof. Trink's paper.)

The pole point having been laid off, the sloping lines of the equilibrium polygon are drawn in the lower sketch, from the pole P to points 1, 2, etc. Lines are then drawn in the upper sketch, parallel to these sloping lines in the lower sketch. Thus, from the point 1′ on the base line at the first median line to the left of the roll middle point, a sloping line is drawn parallel to line P-1 to intersect the second median line at 2′; from this intersection a line parallel to P-2 is drawn to intersect the third median line at 3′; and so on. The "curve" consisting of sections of straight lines 1′ – 2′ – 3′, etc., then gives the bending deflection of the roll, to the scale M, at all points along the length. The greater the number of spaces or divisions used, the greater is the accuracy.

This simple example was chosen because the exact analytical solution for it is known, namely

$$\frac{\text{Deflection}}{(a)} = \frac{p}{EI}\left\{(L-x)^4 - \frac{L^3x}{6} + \frac{L^4}{24}\right\} \quad \ldots\ldots (2)$$

and at x = L this reduces to $-(pL^4/8EI)$. This permits checking the graphical results.

For the condition of Figure 5c, with a single concentrated load P (lb), due to the bearing reaction, acting at a distance Q from the middle of the roll length, the equation for the bending deflection is also known; for constant cross section it is:

$$\frac{\text{Deflection}}{(c)} = \frac{P}{EI}\left\{\frac{(Q-x)^3}{6} - \frac{Q^2\,(Q-x)}{2} + \frac{Q^3}{3}\right\} \quad \ldots\ldots (3)$$

These equations being simple to apply, there was no reason to use the graphical method for the conditions of either (a) or (c) in Figure 5. The graphical method for finding the bending deflection was used only for the deflection caused by the pressure of the work roll and backup roll on each other, as in Figure 5b. The layout for this is shown in Figure 9. The moment curve is not shown, but the equilibrium polygon appears at the upper left. The deflection shown by the curves in the right-hand part of Figure 8 is the sum of the deflection of the work roll plus that of the backup roll, for the condition of Figure 5b. This is obtained by substituting for EI in equation (1) the expression

$$\frac{1}{\dfrac{1}{E_1I_1} + \dfrac{1}{E_2I_2}}$$

where the subscripts 1 and 2 refer to the work roll and the backup roll, respectively. ▲

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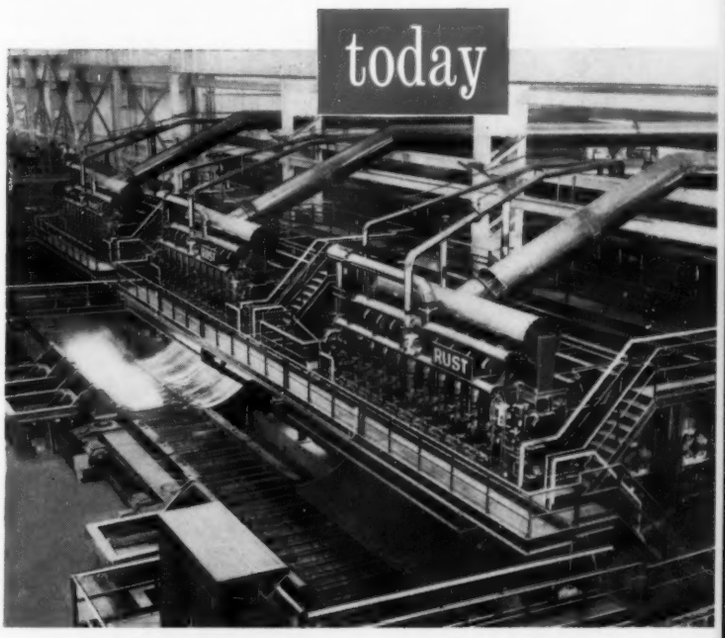

Modern three-zone, continuous furnace now reheating slabs for Kaiser Steel Corp. 86" Hot Strip Mill, Fontana, Calif.

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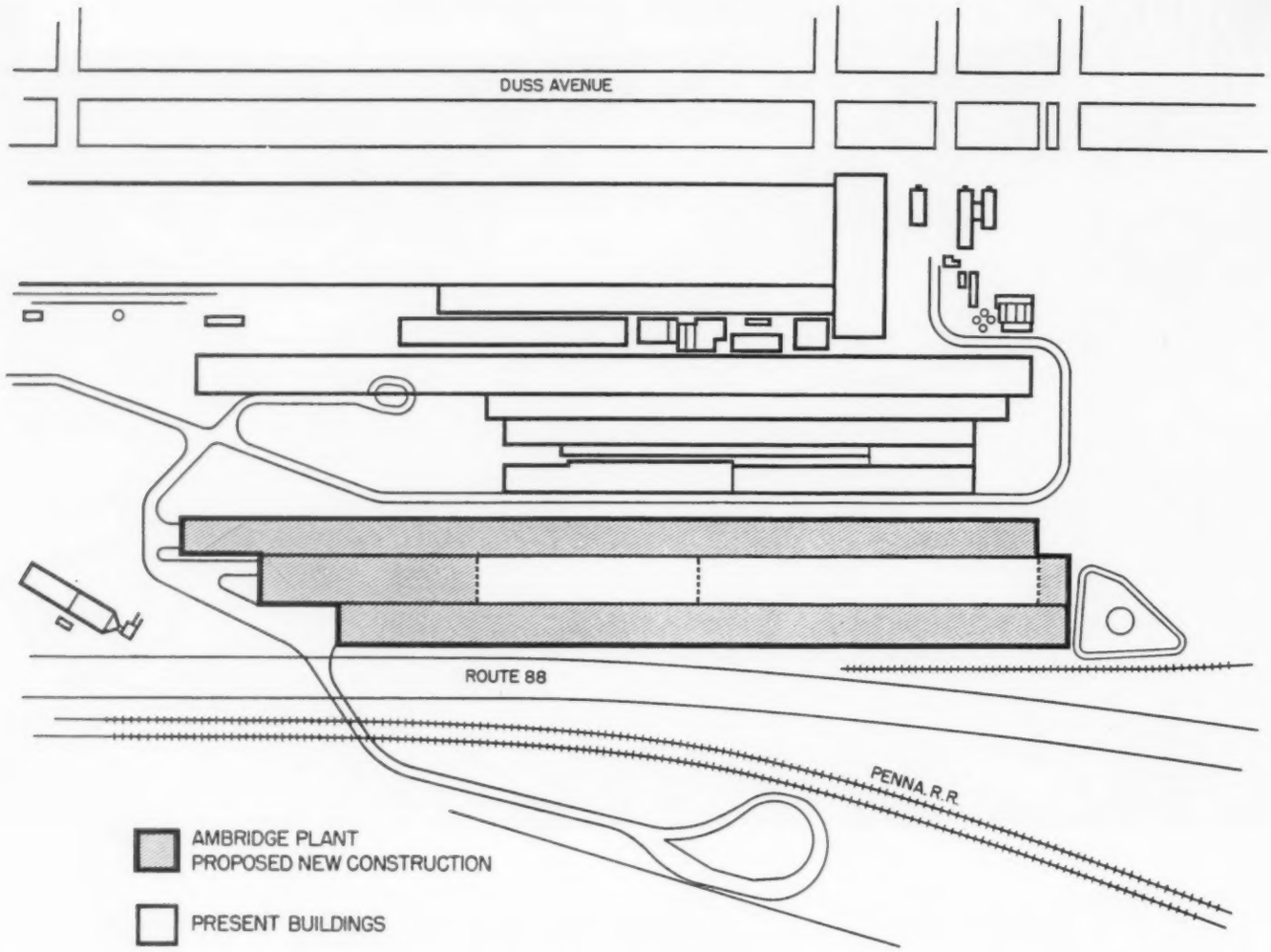


Figure 1 — New construction, which will increase size of Ambridge plant of The National Supply Co. more than 50 per cent, is indicated in this diagram. Two white areas, in the middle of the darkened section, represent the present pipe storage building and pipe storage crane runway. New buildings will be integrated with the present structure. The new mill will be more than a third of a mile long, at its longest point, and 300 ft wide.

National Supply Co. To Install Combination Pipe Mill

A COMBINATION pipe mill that will make either continuous weld or electric weld steel pipe, and that also can be used to stretch-reduce seamless pipe to smaller sizes, will be installed at the Ambridge, Pa., plant of The National Supply Co. Construction started in November, and completion is expected by the middle of 1962.

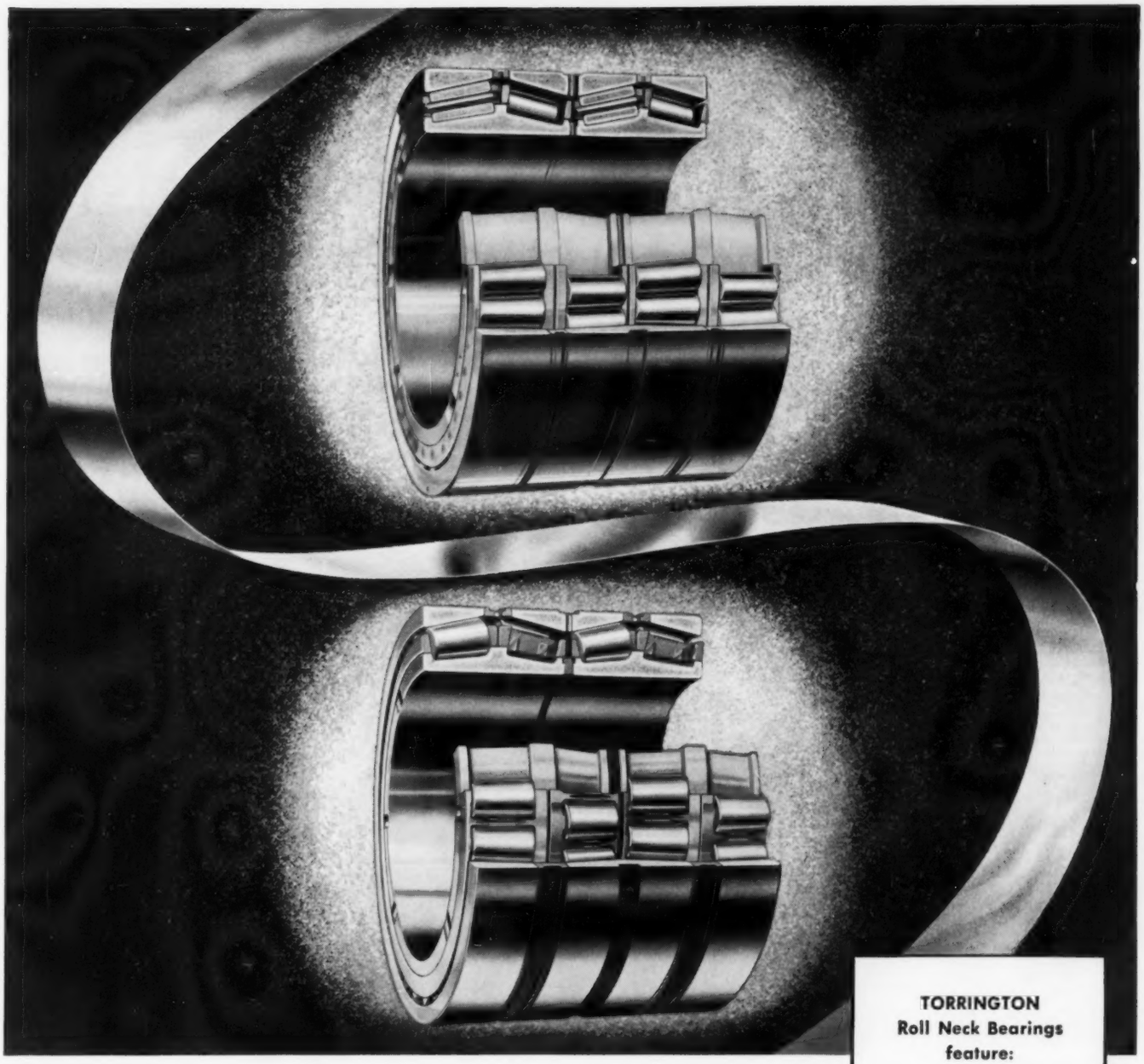
The new mill will combine a 9-stand forming and electric welding mill, an 8-stand welding and reducing mill, a 20-stand stretch-reducing mill and a 3-stand sizing mill, together with furnaces and other equipment.

Facilities will include a new automatic hot-dip galvanizing line and all the necessary finishing equipment for producing rigid steel conduit and electrical metallic tubing. A new plating line will be provided for electroplating EWT and for electroplating the threads on rigid conduit.

The mill and other equipment, together with warehouses for skelp, pipe and conduit, will be located in new buildings to be erected. Containing more than a half million square feet of floor space, these buildings will increase the plant's manufacturing area by more than 50 per cent.

The multi-million dollar improvement is part of a $95,000,000 construction program announced recently by Armco Steel Corp. of which National Supply is a subsidiary. The program also includes major facilities in Armco plants at Ashland, Ky., and Houston, Texas.

With the completion of the new mill, National Supply will make all of its steel pipe and electrical conduit at the Ambridge plant. Previously, the Ambridge plant specialized in making seamless tubular



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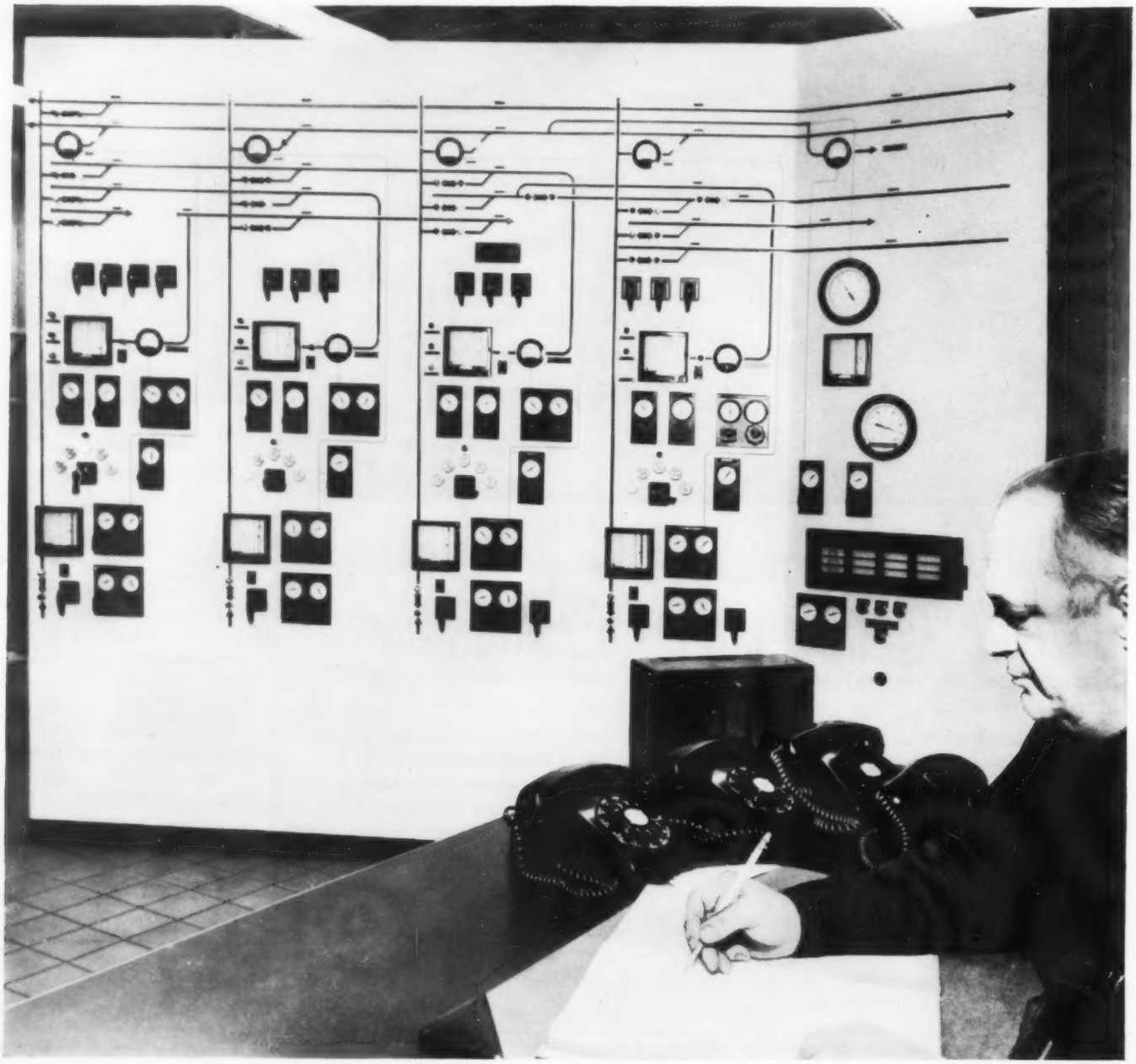
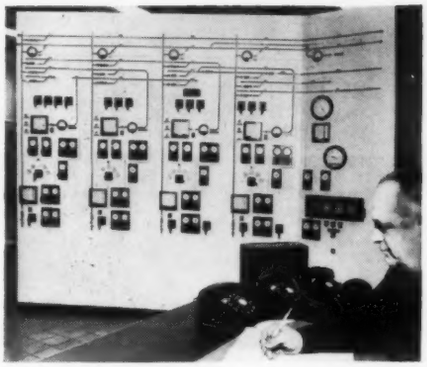
LOWER BLAST FURNACE BLOWING COSTS WITH HAGAN SPLIT-WIND CONTROL

Designed for future expansion, the graphic control panel is programmed in this manner: ■ No. 4 Turbo is blowing Furnace No. 11. Its excess capacity is "spilling-over" to augment the wind from No. 2 Turbo. ■ No. 2 Turbo is blowing Furnace Nos. 9 and 12, with the additional wind from the "spill-header." ■ No. 6 Turbo is blowing No. 10 Furnace.





Today, split-wind blowing makes it possible for existing turbo-blower capacity to meet the constantly increasing wind requirements of rebuilt, enlarged blast furnaces and to do this at maximum possible efficiency.

A control system, to accomplish this objective, must provide centralized control for operator economy, and the flexibility needed to achieve high blowing efficiencies regardless of varying flow and pressure requirements.

In the system shown, installed at the Gary Works of U.S. Steel, three blowers supply blast air to four furnaces, with a fourth blower on operating standby. Normally, one turbo blows the furnace requiring the highest blast pressure. Excess wind passes into a spill-header and is used to augment the wind from the other active blowers.

The graphic control panel makes true centralized control possible by performing the following functions: shows the position of all control and shut-off valves—indicates and records the flow and pressure to each furnace—shows configuration of manifolding to blow the furnaces—provides communications between the control room and the cast house floor—records and indicates flow and pressure of each blower—provides remote manual operation of the shut-off valves—gives operators a means of changing furnace flow set point and manifold pressure.

For more information, write for Bulletin "Hagan Blast Furnace Control Systems."

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products. Welded pipe and conduit were made at Etna, Pa. The Etna plant in the Pittsburgh area is to be closed.

The new mill, one of the most modern combination pipe mills in the world, will produce continuous weld pipe in nominal pipe sizes from ½ to 4 in., and electric weld pipe in diameters from ½ nominal to 7 in. outside diameter, with a maximum speed of 2000 fpm.

The same stretch-reducing equipment will be used to stretch-reduce 4½-in. to 7-in. outside diameter seamless pipe into nominal pipe sizes from ½ to 4 in. The electric weld pipe, and the smaller sizes of seamless pipe, will be new products for the company.

CONTINUOUS WELD PIPE

In producing continuous weld pipe, the strip steel will be uncoiled and leveled, cold-formed into an open-seam tube, and heated to approximately 1800 F, and then the edges will be heated to 2450 F. In the 8-stand welding and reducing mill, the tube will be welded into a 5.384-in. tube and reduced to a 4.690-in. tube. After passing through a furnace to equalize its temperature to approximately 1950 F., it will pass through the 20-stand mill, to be stretch-reduced to the desired final diameter.

The pipe will be cut into lengths varying from 84 to 100 ft by a flying hot saw. It will be sized, if necessary, through the 3-stand sizing mill, cooled, and cut to 21 to 25-foot lengths. Finishing operations will include straightening; reaming, facing, and chamfering; and testing; together with galvanizing and threading, as required.

ELECTRIC WELD PIPE

In producing electric weld pipe, the strip, after leveling, will pass through a Wheelabrator before entering the cold forming mill. After cold forming, the tube will pass under an electric resistance welder through the necessary pull-out, sizing and decambering stands.

After the inside and outside weld flash is trimmed, the tube will be cut by a flying rotary cutter into lengths about 200 ft long. These 200-ft lengths will be flushed inside, and then fed into a furnace for heating to temperatures between 1600 and 1800 F.

Electric weld pipe for final nominal pipe sizes from ½ to 4 in. will "dummy" through the edge-heating furnace, and be reduced in the 8-stand welding and reducing mill, and then heated to 1950 F in the equalizing furnace before passing through the stretch-reducing mill and the flying hot saw to the cooling table.

Electric weld pipe for final sizes over 4½ in. outside diameter will be cut to length ahead of the first reheating furnace. After the stretch-reducing mill, which will be used as a sizing mill, the pipe will be taken off on a cross-transfer cooling table.

STRETCH-REDUCING SEAMLESS PIPE

Seamless pipe from either of the two seamless mills at Ambridge, can be stretch-reduced on the new equipment. Placed on the cross-transfer table ahead of the heating furnace, it will be fed into the furnace and dummy through the 8-stand welding and reducing mill, for stretch-reducing to nominal pipe sizes ½ to 4 in.

ETNA PLANT

National Supply's Etna plant is the outgrowth of a small plant established in 1828 to make farm implements. In 1840 it began making iron pipe, the first made west of the Alleghenie's. In the 1930's it became the third plant in the world to make steel pipe by the continuous weld method.

Employees of this plant were told that the new mill is necessary for lower operating costs, increased efficiency and highest quality, but cannot be accommodated within the layout of the Etna plant.

The plant will be shut down by departments, starting with lapweld finishing, a comparatively small operation, on November 30. The continuous weld furnaces will be kept in operation until April 29, 1961. Galvanizing, finishing and certain shipping operations will continue until later dates, with the final shipment on August 31, 1961.

Many employees will be eligible for pensions, and most others will receive severance allowances. The severance payments alone will cost the company nearly $1,000,000. ▲

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J & L Installs Computers on Steelmaking and Annealing Units

A NEW electronic computer, which works out the proper "recipe" for making steel in the basic oxygen furnace, has been installed at the Aliquippa, Pa., Works of Jones & Laughlin Steel Corp.

The special-purpose analog computer calculates the proper proportions of hot metal, scrap and lime to be charged into the furnace so any desired type of steel may be tapped at the desired temperature. The tapping or finishing temperature in this new steelmaking process plays an important role in the quality of the product.

This unique application of mathematics and computers was developed by the J & L research staff to put scientific theories to work in actual steelmaking production.

It also marks a technological advance in the basic oxygen steelmaking process—a process which is being watched with increasing enthusiasm in the steel industry.

J&L also has under construction what will be the two largest basic oxygen furnaces in the world at its Cleveland, Ohio, Works.

One of the critical phases of steelmaking is to finish a heat of steel within a selected tapping or finishing temperature range, for example 2880 to 2920 F. Because of the nature of the process, this temperature is controlled, to a large degree, by the amount of cold scrap used in the initial charge to the furnace.

In the past, operating personnel had to rely on their experience and technical knowledge to determine the quantities of scrap needed to give the desired tapping temperature. When the finishing temperature was outside the specified range, the molten steel had to be "reblown" briefly to attain a higher temperature, or cooled by further addition of scrap. This delayed production because of the extra time required to make these adjustments.

To solve this problem a set of mathematical equations was developed at the Graham Laboratory which made possible advance calculation of the quantities of scrap, fluxing materials, and hot metal needed for any specified tapping temperature.

The theories, which were developed on J&L's analog computer, were tested on-the-spot with a special-purpose, slide rule type of computer designed from the mathematical model of the process. It then was decided that an electronic computer would be more useful to operating personnel, not only because of its greater accuracy, but also for its ease of operation.

The new computer was designed and manufactured by Electronics Associates, Inc., of Long Branch, N. J.

Iron temperature, utilized in the computations, is recorded by a two-color pyrometer sighted on the molten iron as it is poured from the blast furnace iron mixer car to the iron charging ladle.

To compute the charge for a heat of steel, the melter at the basic oxygen furnace department sets the computer's potentiometers for the desired charge weight, tap temperature, basicity ratio, lance height, scale and ore additions plus the measured iron silicon, iron manganese and iron temperature. The advance control button then is pressed. This places the computer in the "print" mode where all inputs are recorded on paper tape.

After the print operation, which requires approximately five seconds, the control button advances the computer to the "compute" position where the control equations are solved for the given input conditions. When the operator pushes the control button three more times, the computer immediately displays, in turn, the desired quantities of scrap, hot metal and lime.

ANNEALING LINE

An electronic computer, that makes decisions and has a memory, is also controlling production and quality on the new continuous annealing line at the Aliquippa, Pa., Works of Jones & Laughlin Steel Corp. Known as a digital control computer system, the equipment is believed to be the most complex computer system in the steel industry. The new system controls variables in the annealing process to achieve greater efficiency and a more uniform product. Its other functions include data acquisition, production analysis and accounting.

The following are some of the things the computer does:

1. Plots a method of operation whereby the continuous annealing

Figure 1 — A special-purpose analog computer which can calculate the proper ratio of hot metal, scrap, and lime for the basic oxygen steelmaking furnace has been installed at the Aliquippa, Pa., works of Jones & Laughlin Steel Corp. Here a melter computes the proper ratio for the most efficient tapping temperature for a heat of steel.

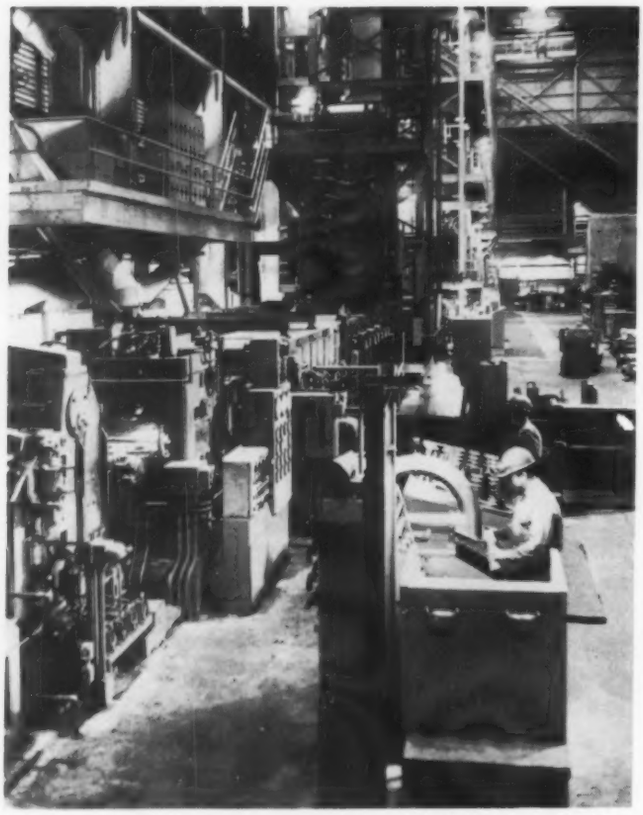


Figure 2 (left) — The loader on the continuous annealing line prepares to pass along information concerning a coil of strip steel in the operation of a new digital computer control system. A punched card containing production information is fed into the computer here at the entry end of the annealing line. A corresponding identification tag is then sent to the line's discharge end where additional data on the actual annealing process is typed on it by the computer. This maintains an immediate record for each coil.

Figure 3 (right) — A coil ticket containing various production and accounting information is printed by a new digital computer on the continuous annealing line. The new computer types out this information on a data log typewriter as a coil of strip steel concludes its cycle through the annealing line.

line can be run at its most efficient speed and with the greatest product quality without abuse of the equipment.

2. Provides "instant" accounting records on punched tape for each coil of steel as it emerges from the line.

3. Reduces furnace downtime by checking the various sensory devices within the furnace for off-normal practices or conditions.

4. Provides timely, accurate operating data in typewritten form, enabling operators to make production decisions with a minimum of interpretation.

5. Provides increased knowledge of the continuous annealing process which will permit better design in future annealing lines.

6. Possesses the capability of being reprogrammed to match advances in the art of annealing and in computer control.

The computer also possesses the unique ability to recognize abnormal conditions or failures, not only in the line but also in its own performance.

It is the first computer of its type ever installed on a continuous annealing line or a steel processing line of any type.

The complexity of the new J&L computer is due to the many variables in the annealing process with which it deals. Most industrial computers control only one or two variable factors.

The annealing process is continuous, and the cold rolled steel may vary in its dimensions. Thus, steel of certain gage and width and requiring a certain specified annealing practice may be welded to another coil of steel of different dimensions and requiring a different annealing practice.

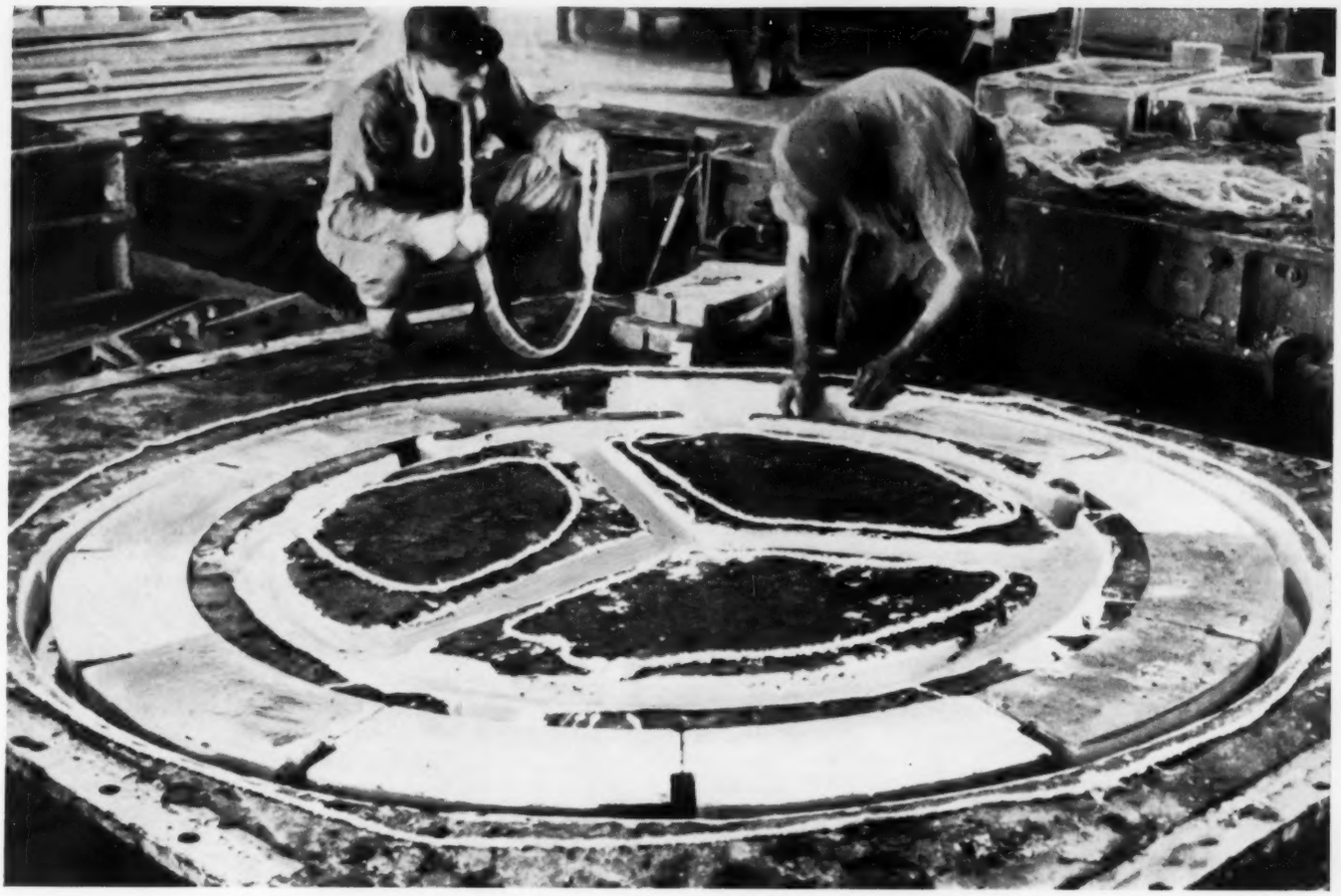
The process also may be affected by chemical composition of the strip steel, variations in time and temperature of the annealing furnace, and brightness or heat-absorbing capacity of the strip.

The computer system facilitates the operation of this continuous process by automatically tracking each coil of steel through the line and regulating furnace speed and temperature to achieve the proper annealing cycle, despite the varying requirements.

The finished product is inspected and classified automatically, making quality records for each coil instantly available. The computer system also monitors line operation and collects and computes the data required to analyze characteristics of the process. Incentive and administrative records also are prepared on punched tape while the coil is in process.

The computer system has been installed on the furnace zone temperature regulators. A selector system also has been installed whereby any one or all furnace zones can be controlled manually.

In the operation of the computer, operating data such as steel width, thickness, chemical analysis, desired annealed hardness, steel grade and



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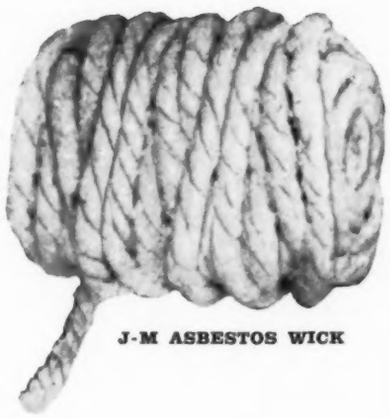

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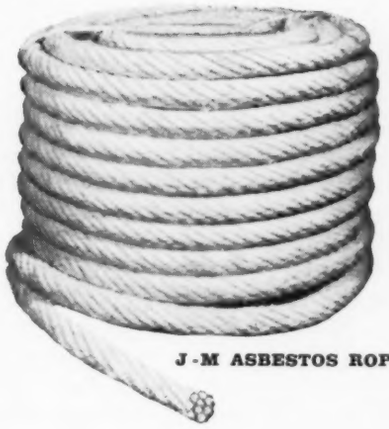

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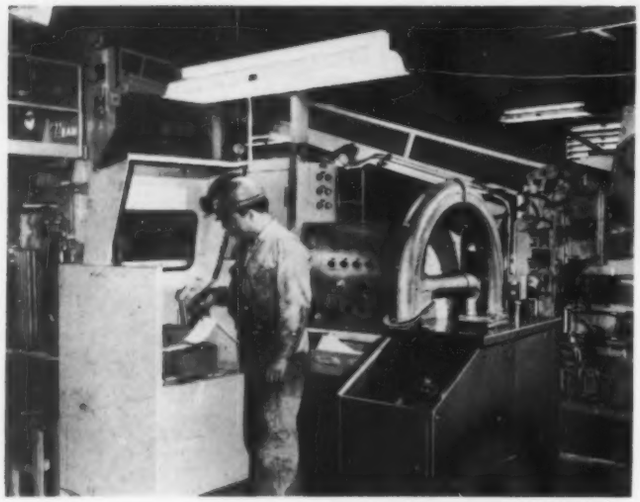

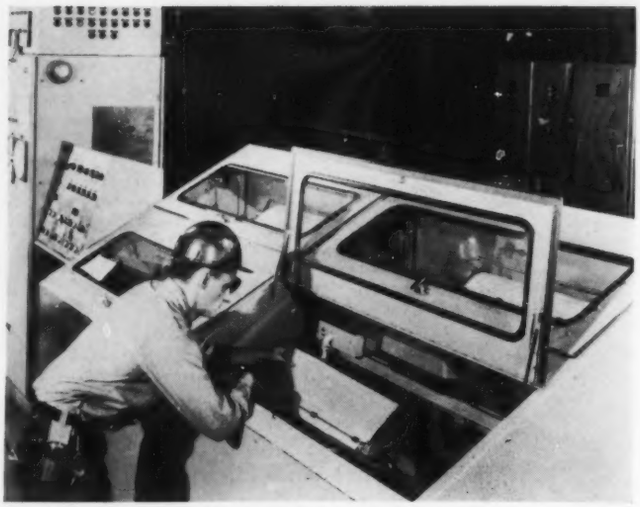

Figure 4 (left) — The loader inserts a punched card into the computer "card reader" as a new coil enters the line. He also will select switches at his right to record the coil number, weight and inventory code.

Figure 5 (right) — Observing the report of the computer as it "checks" itself is the annealing line operator.

a specified line operating speed are prepared on a punched card. The card also contains order accounting data such as the order number, heat number, incentive pay standard code, coil diversion code and the promised shipping date.

As the coil enters the line, the punched card prepared for that order and heat number is inserted into a card reader at the entry coil holder. The operator then selects switches at the entry end for the coil number, weight, and inventory code.

As the head end of one coil is welded to the tail end of the preceding coil, the welder signals the computer to "read" the entry card reader and the manual input data. The computer also "remembers" the position of the weld.

The entry section then is restarted, and the new coil enters the line. Pulse type tachometers on the furnace section and at the delivery section provide a signal to the computer for each foot of steel that passes through these sections.

The computer will track the welds from the entry welder through the entire line. As the weld marking the head end of each coil reaches the guides before and at the end of the furnace, the computer will check the order data to determine whether the strip following the weld is wider than that preceding it. If it is, the sideguards will be opened automatically and an alarm sounded at the operator station. The operator then can adjust the position of the sideguards.

As the head end of a new coil or order reaches the furnace, the computer will reset the furnace temperature controls to the specified values, as indicated on the order cards.

Inspection devices at the delivery end of the line inspect and classify each foot of steel strip, and as the weld marking the end of each coil passes the delivery shear, the identity data fed in at the entry end for that coil are typed automatically on a coil log typewriter at the annealer's station. The computer also flashes the position of each weld in the furnace by means of signal lights, and warns of a weld approach at the delivery end of the line. Thus, operators can prepare for shearing operations.

When the weld at the end of a coil is sheared, the computer types out all footage classification data for that coil on the coil log typewriter at the annealer's station. The log includes the total footage in the coil, footage in each defect category if any, the coil weight, percentage of prime product, percentage in each defect category if any, and the time required for processing the coil.

A coil ticket is printed automatically with the operation of the shear at the delivery end of the line. This ticket is an identification tag which includes the line number, the mill work shift, the crew identity code, date, coil number and weight and a coil diversion code computed from the percentage of prime product.

The computer records all furnace delays, and automatically types the clock time, time elapsed and other delay data on the coil log typewriter. It tracks any footage which may be ruined by a delay in the furnace.

The computer also "checks" the performance of the line every 10 seconds and every 10 minutes provides an over-all picture of the various sensing devices recorded on the data typewriter.

Reliability of the computer system is increased by a series of tests performed by the equipment itself. Periodically, it performs a series of programmed calculations, exercising as many of its components and elements as possible. The resulting signals are checked against known correct values to determine any discrepancies.

The computer also is programmed to examine for reasonableness, signals from the various sensing devices. An alarm is sounded if any of the sensing devices transmits an unreasonable signal.

The final protective program is known as a "mad man" sequence. This provides for a check against the possibility that the computer may "go mad," perform illogical operations, and lose the ability to check itself. This is accomplished by a check in operations, at certain specified times. If this check is not made, a lock-out relay is energized, and the computer is automatically shut down.

Requirements for the computer were developed by J&L engineers, and the computer was designed by General Electric Co., and built by General Electric Computer Department, Phoenix, Ariz. ▲

LINK-BELT GEARMOTORS . . .

cool-running!
quiet!
compact!

Where inches count . . .
LINK-BELT Gearmotors
make the most of mounting space

If you're after (1) high-efficiency speed reduction (2) performed in close quarters—look no longer. You get the best of both with Link-Belt Gearmotors.

• COOL-RUNNING—due to precision-cut, hardened gear trains that minimize friction.

• QUIET—a result of smooth-meshing gears and cast-iron, one-piece housing.

• COMPACT—because of simple gear trains and flange-connected motor that requires no additional coupling devices.

Available in double, triple and quadruple reductions—ratios from 6.2:1 to 985:1 . . . up to 100 hp.

FOR FULL-LINE FACTS

on Link-Belt's comprehensive line of speed reducers—contact your nearest Link-Belt office or authorized stock-carrying distributor . . . or check and send this coupon to Link-Belt Company for data on all or any combination of the following:

- ☒ gearmotors
- ☐ motogears
- ☐ helical gear speed reducers
- ☐ shaft-mounted speed reducers
- ☐ worm gear speed reducers
- ☐ universal worm gear speed reducers
- ☐ parallel shaft speed reducers
- ☐ fluid drives
- ☐ P.I.V. speed changers

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Eases toothless saw through toughest steel in seconds

Louis Allis motor powers high-speed steel cutter

Powered by a Louis Allis 200-hp high-torque squirrel cage motor, the friction saw shown above zips through steel like a hot knife through butter. The blade-edge, traveling at more than 300 miles per hour, generates enough frictional heat at the point of contact to actually *melt* its way through an 8 in. steel pipe section in 3.25 seconds — a 100 lb. rail in 4 seconds — a 12 in. I-beam in 5.7 seconds.

These extremely high cutting rates and the hydraulic carriage drives of these machines require high torques subjecting the motors to severe loading conditions. That's why the manufacturer of this heavy-duty friction saw selected Louis Allis motors for dependable power supply to blade and carriage drives.

Whether it's for cutting steel or for any other demanding application, Louis Allis can provide the motor you need. Our engineers will help you select the exact rating, speed, and enclosure your job requires. What's more, they can recommend electrical and mechanical modifications that may improve your operation, reduce costs, and provide long, trouble-free motor life.

For facts or engineering assistance, contact your nearby Louis Allis District Office. Or write The Louis Allis Co., 450 E. Stewart St., Milwaukee 1, Wis.

LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

Allegheny Ludlum Starts Two Continuous Bright Annealing Lines

ALLEGHENY Ludlum Steel Corp. announced that it is producing, in commercial tonnages at two locations, a new "bright-annealed" stainless steel with a mirror-like finish and improved corrosion-resistant qualities. The product is going into the 1961 automobiles, into appliances, and other products.

This new product represents a major improvement in the surface lustre and corrosion-resistance of stainless steel.

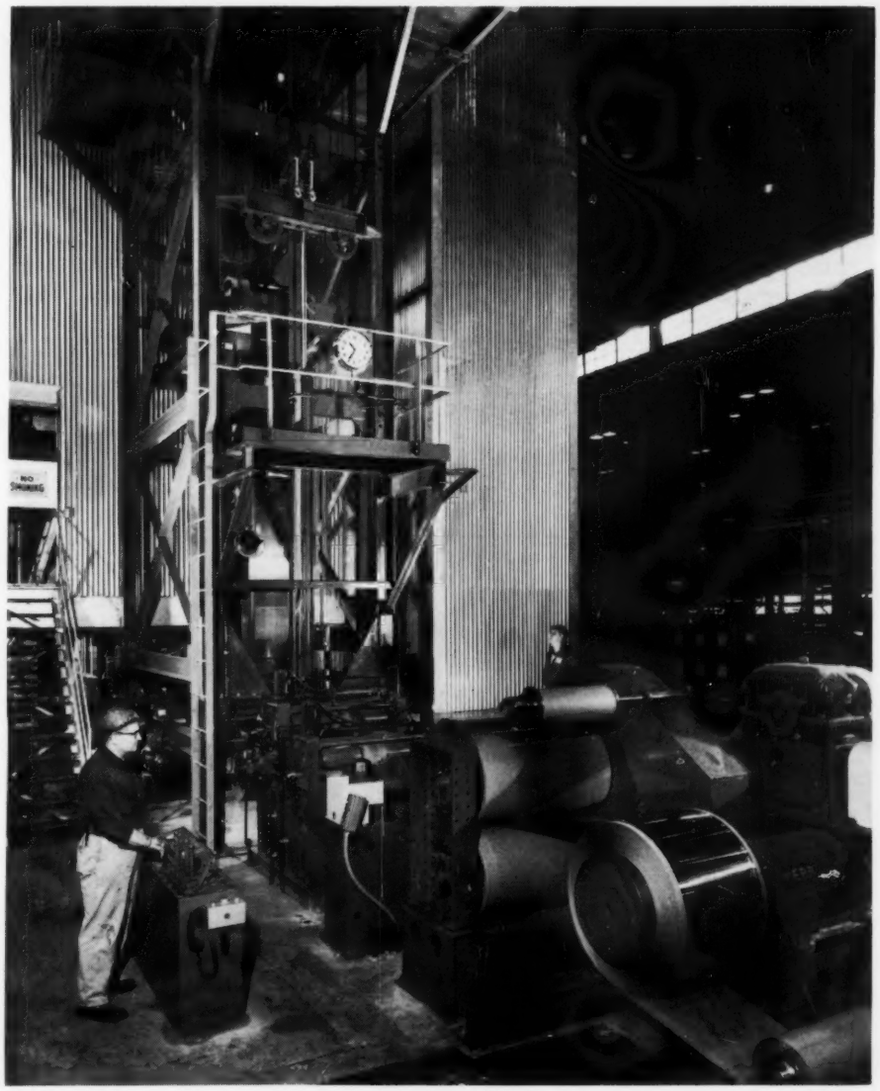
"Bright-annealed" stainless is being produced in new facilities at the company's West Leechburg, Pa., Works and at the Wallingford, Conn., plant of its subsidiary, the Wallingford Steel Co. Large new vertical electric furnaces for continuous bright-annealing of stainless steel strip, up to 27 in. in width, have been placed in operation at the two plants. These furnaces, which are about 100 ft high, are the largest and most advanced bright-annealing units in production in the steel industry. Built by General Electric Co., they are the first furnaces in the industry to produce bright-annealed stainless strip in commercial tonnages in a broad range of types and sizes of stainless.

The key to success of the new process is that stainless steel strip is annealed in a controlled atmosphere and under rigidly-controlled temperature conditions while moving between high-purity refractories. Where conventional annealing dulls the surface of the metal, requiring further pickling to restore brightness, the new furnaces retain optimum surface brightness of the strip. Because of its mirror-like finish, the strip can be fabricated and put in place on an auto with a minimum of buffing and other finishing. The latter quality makes possible substantial cost savings for the manufacturer.

Allegheny Ludlum and Wallingford Steel are offering the new product at no additional cost over conventional stainless steel.

The new furnaces of Allegheny Ludlum and Wallingford—represent a combined capital investment of more than $2,000,000. ▲

Figure 1 — Exit side of the new continuous bright-anneal furnace at West Leechburg works of Allegheny Ludlum Steel Corp. The furnace itself, inside the ribbed tower in background, is about 100 ft high.



Ceramic Lining Adds Flexibility To Centrifugal Cast Pipe Process

THE modern answer to an old size problem in steel tubing is a new centrifugal casting process recently developed by the Special Products Division, American Cast Iron Pipe Co., Birmingham, Ala., with this process engineers can specify the *exact* outside diameter and wall thickness of tubing to meet specific design requirements for high-pressure, high-temperature piping and for tubular mechanical components such as rolls and hydraulic cylinders. The new process eliminates the need for special dies or patterns, and engineers are no longer limited to commercially available standard pipe sizes.

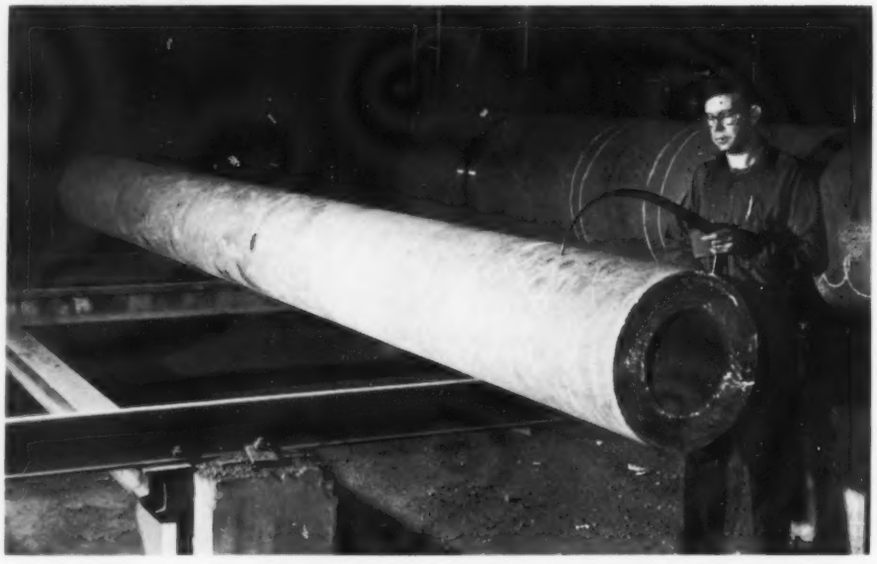
Called the Acipco Ceram-spun process, the great improvement in size range and size selectivity has been made possible by using *ceramic-lined* metal flasks for casting the molten steel or other metal compositions. Older methods of centrifugal casting use either metal molds with a sprayed refractory facing or sand molds rammed around a cylindrical pattern inside a metal flask. The ceramic lining is produced centrifugally in much the same manner as the tubes themselves, by pouring a ceramic slurry into a rapidly spinning metal flask. Centrifugal force separates water from the denser ceramic particles and at the same time forces finely divided ceramic particles to the inside surface of the mold. The water is then drained from the mold. Subsequent baking of the mold produces a hard ceramic lining of uniform diameter and high density. Steel tubes cast in molds of this type are remarkably free of imperfections such as hot tears and cracks frequently found in tubes made by older methods.

By simply varying the thickness of the ceramic lining, a wide range of outside diameters can be made in a metal flask of a given size. Thus, with a relatively small number of flask sizes, steel tubes with outside diameters ranging in innumerable variations from 2.25 to 50.00 in. can be produced in wall thicknesses from 0.25 to 8.00 in. The standard length is 20 ft, but shorter lengths can be produced at slightly additional cost by use of mold stops.

Other advantages of the process include flexibility in metal composition, high casting yields, nondirectional tensile properties, excellent weldability and machineability, and a high degree of mechanical integrity. Heat treating facilities are available for annealing, normalizing and tempering, or quenching and tempering.

Tubes are produced in carbon steel, low alloy steel, heat resistant and corrosion resistant stainless steels and both plain and alloy cast iron. Lengths longer than 20 ft can be produced in most grades of steel by submerged arc welding. ▲

Figure 1 — This heavy wall steel tube was cast 18.20 in. OD by 10.70 in. ID by 20 ft long to the requirements of ASTM Specification A-216, Grade WCB. It will be bored to 12.50 in. ID and fabricated into two unfired pressure vessels approximately 10 ft long.



SKELETON IN THE SKY

Perfectly at home in the maze of girders and hangers that will soon support a giant boiler are these steel workers and boilermakers. Our experienced teams have proved repeatedly their ability to complete projects on schedule and within the budget. United Engineers has served many of the country's leading steel producers on projects of widest size and complexity—designing and installing rolling mills, coal-chemical facilities, power plants and other equipment. Each project demonstrates the time and cost-saving advantages in our coordination of design, purchasing, expediting and construction. We invite you to share and profit from our background of 75 years' experience as designers, construction engineers, and engineering consultants.

Painting by Stanley Meltzoff

Helping the steel industry grow

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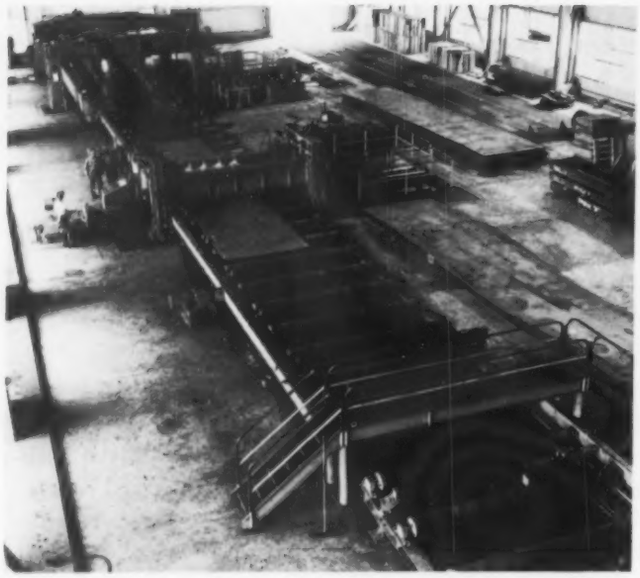


Figure 1 (left) — Plate begins 1000-ft run through Bethlehem Steel Co.'s new line pipe mill at Steelton, Pa., by entering side planer (far background). This machine planes off up to ½ in. on each side of the plate with 12 cutting tools. Both sides are planed simultaneously in about two minutes. Plate then rolls to an end planer where four photoelectric cells automatically stop it in the proper position for cutting to size. Plate is first clamped and cut on the leading end; then moved, stopped again by electric eye, and clamped and cut on the trailing end.

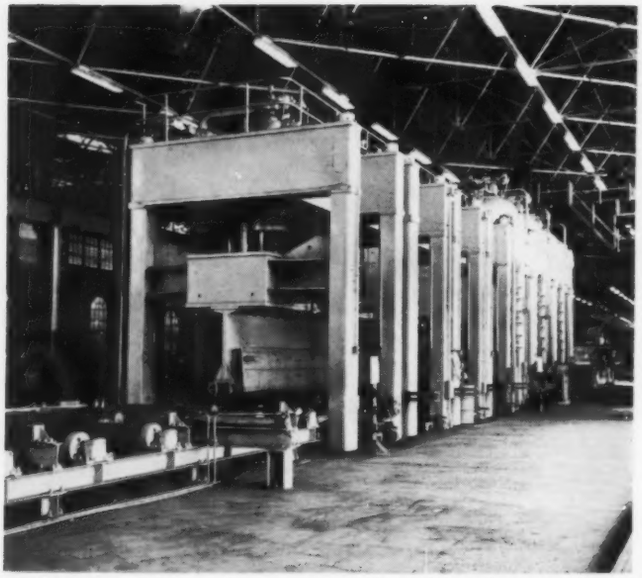


Figure 2 (right) — Plate moves to 2500-ton-capacity hydraulic U-ing press, where the male punch presses down, ward in the center of the plate and the rocker die, below-tilts upward on each side. In about one minute the plate is shaped into a long U.

Bethlehem Triples Gas Pipe Production Capacity at Steelton

HIGH-strength large-diameter steel pipe for cross-country transmission of high-pressure natural gas is now being produced at Bethlehem Steel Co's. new expanded line pipe mill at Steelton, Pa.

The new mill is expected to triple gas pipe production at Steelton. Approximately 25,000 tons of line pipe from 18 to 42 in. in outside diameter can be produced each month.

Before the mill went into operation, Bethlehem produced this pipe by first rolling 20-ft lengths of steel plate into cylindrical form, and then butt welding two sections together to form the standard 40-ft length of gas transmission pipe.

Now, Bethlehem forms this pipe on two presses. The first, a 2500-ton hydraulic U-ing press, transforms a 40-ft length of steel plate, up to ¾ in. thick, into a long "U" in about a minute. The second, an 18,000-ton hydraulic press, takes about another minute to complete the shape, turning the "U" into an "O." This quick forming is the key to the rapid production of high-quality pipe at rates up to one 40-ft length every two to three minutes.

OPERATION OF THE MILL

Material for forming the line pipe arrives on rail cars at the Steelton mill from either Bethlehem's Sparrows Point (Md.) or Johnstown (Pa.) plate mill. Plate measures 40 ft-5 in. long and 52 to 130 in. wide, depending upon the diameter of the finished pipe. The plate arrives deliberately oversize, since it loses a few inches in width and length as it is processed down the 1000-ft-long production line. Weight per plate varies from one ton for the 18-in. stock to 7½ tons for the 42-in. size.

Stacks of plate are unloaded from the rail cars by a 20-ton magnet gantry crane and placed on either side of a receiving table, just outside of the 930-ft-long mill building. The automatic feeder then takes over. A one-legged gantry of 15 tons capacity, equipped with suction cups, vacuum-lifts one plate at a time and places it on the receiving table. Powered rolls move the plate from receiving table to feeding table, one at a time.

When the last plate of the stack actuates a limit switch, the one-legged gantry automatically stops in the home position. The gantry is then switched over to pick steel from the other stack of plates. A one-legged gantry was chosen to feed the receiving table because it always gives the magnet gantry crane access to stack the plate on one side of the receiving table or the other.

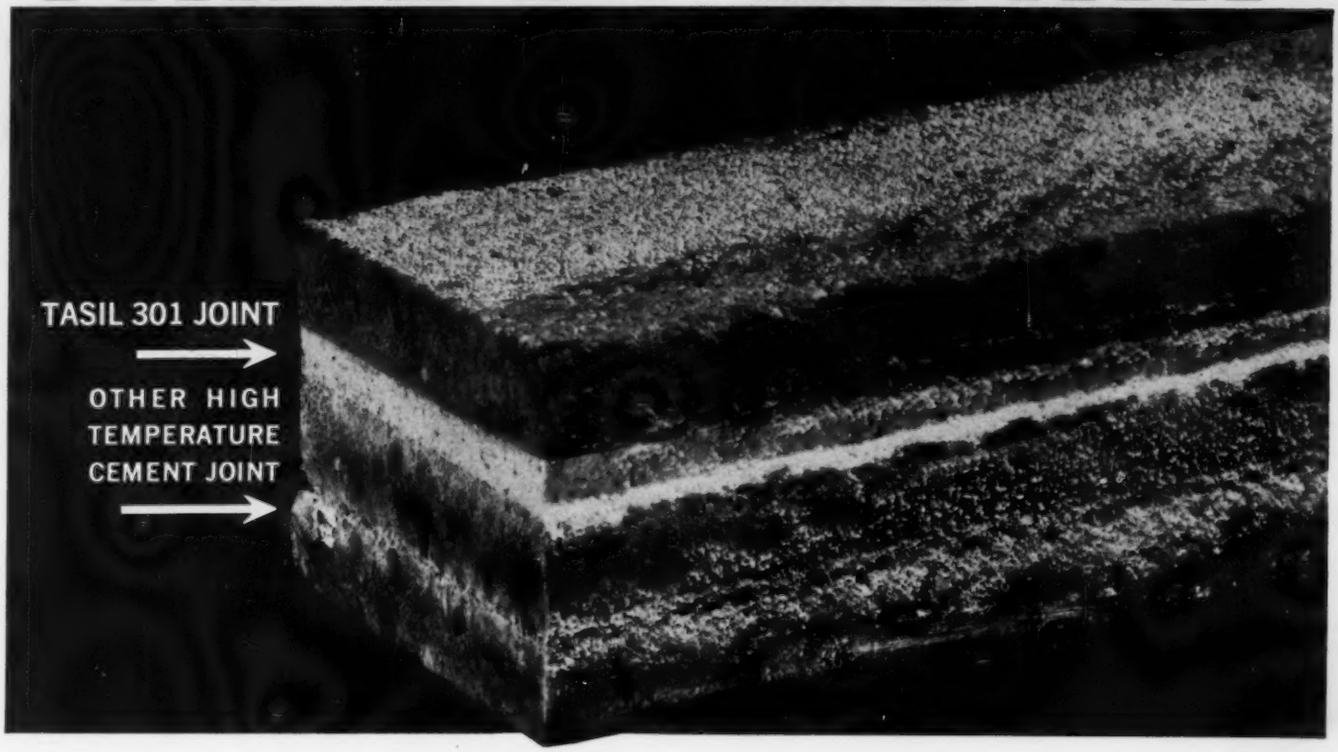
The feeding table moves the plate along, through a slit in the side of the building, directly to the side planer.

The side planer planes off up to one-half inch on each side of the plate with 12 cutting tools. Both sides are planed simultaneously in about two minutes.

The plate then rolls to an end planer where four photoelectric cells automatically stop it in the proper position, for cutting to size. The plate is first clamped and cut on the leading end; then moved, stopped again by electric eye, and clamped and cut on the trailing

(*Please turn to page 203*)

TRIAL BY HEAT...



Superior Refractoriness of TASIL 301 Cement proved by severe test

TEST DETAILS...

Three slices of TAMUL brick were cemented together with approximately ¼" thick joints — one of TASIL 301 Cement, the other a widely used air-setting high temperature cement. After drying, an 11-lb. brick was placed on top of the specimen which was then put in a laboratory re-heat furnace. The specimen was fired to 3000° for five hours, then allowed to cool. The brick was then sectioned, as shown.

Get TASIL Special Refractory Cements in the form you prefer:

No. 301 Air-Setting Cement — ready-mixed in drums.

No. 317 Air-Setting Cement — dry in bags.

No. 302 Heat-Setting Cement — dry in bags.

After five hours at 3000° temperature, the TASIL mortar in this test "sandwich" was unaffected. In the other joint, the cement has melted and run out—permitting the brick to press completely together.

New improved TASIL 301 Cement was developed to pass these specifications:

- **Superior refractoriness . . . high bonding strength . . . improved workability . . . minimum shrinkage at high temperatures . . . maximum resistance to slagging and erosion . . . ability to stay in suspension.**

Get maximum joint protection by using TASIL 301 Cement for your next furnace rebuild.

Call in your Taylor Field Engineer, or write direct for details.

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Oakville, Ont., and Montreal

The CHAS. TAYLOR SONS Co.
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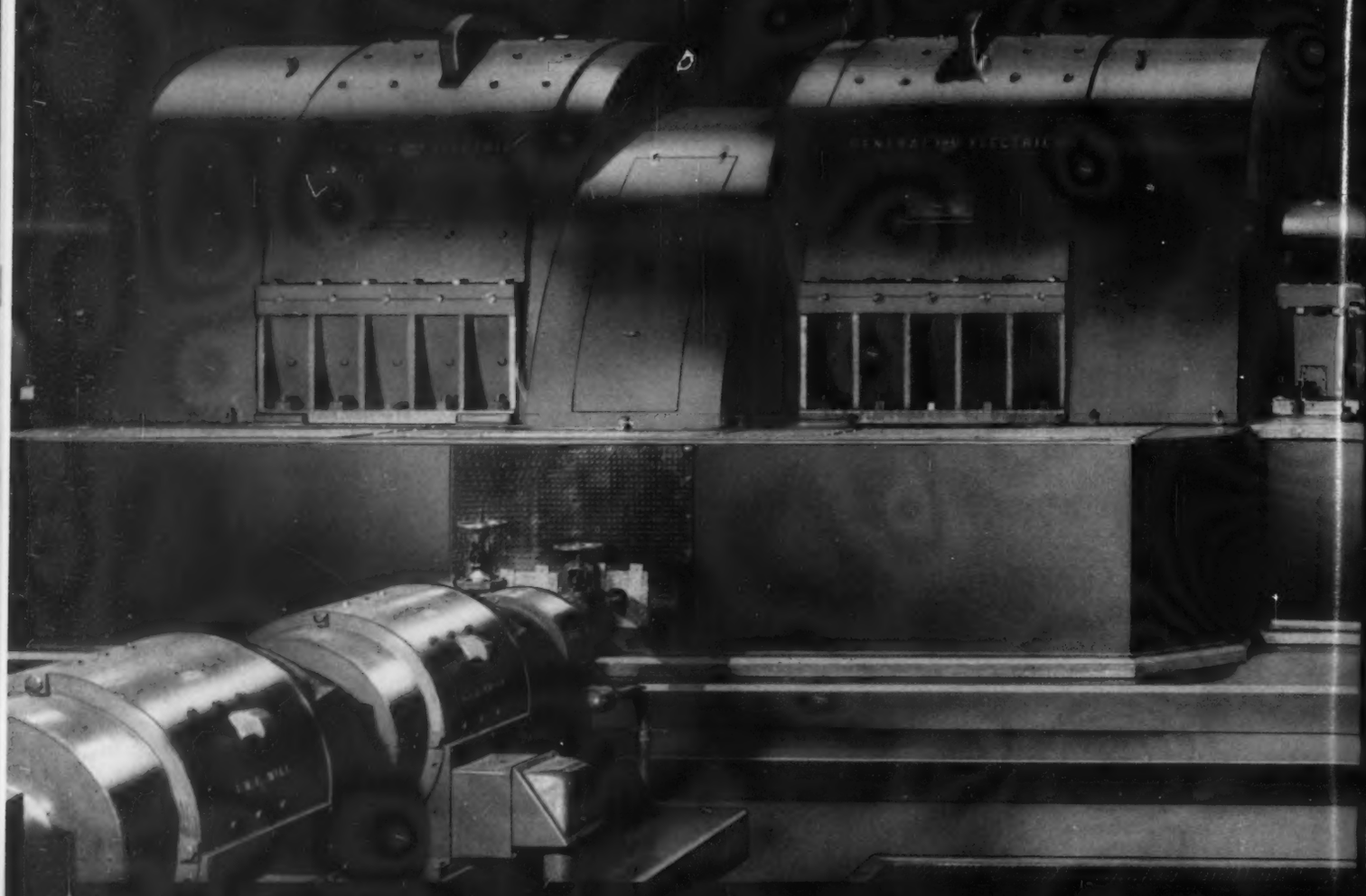
REG. U. S. PAT. OFF.
REFRACTORIES SINCE 1864 • CINCINNATI • OHIO • U. S. A.

Three Reasons General Electric D-C Drives are Best for



1. Costly Maintenance Shutdowns Reduced by

D-c Main Drives

In metal-rolling mills—where minutes of downtime are measured in thousands of dollars—fast, simplified maintenance of main drive motors is critical.

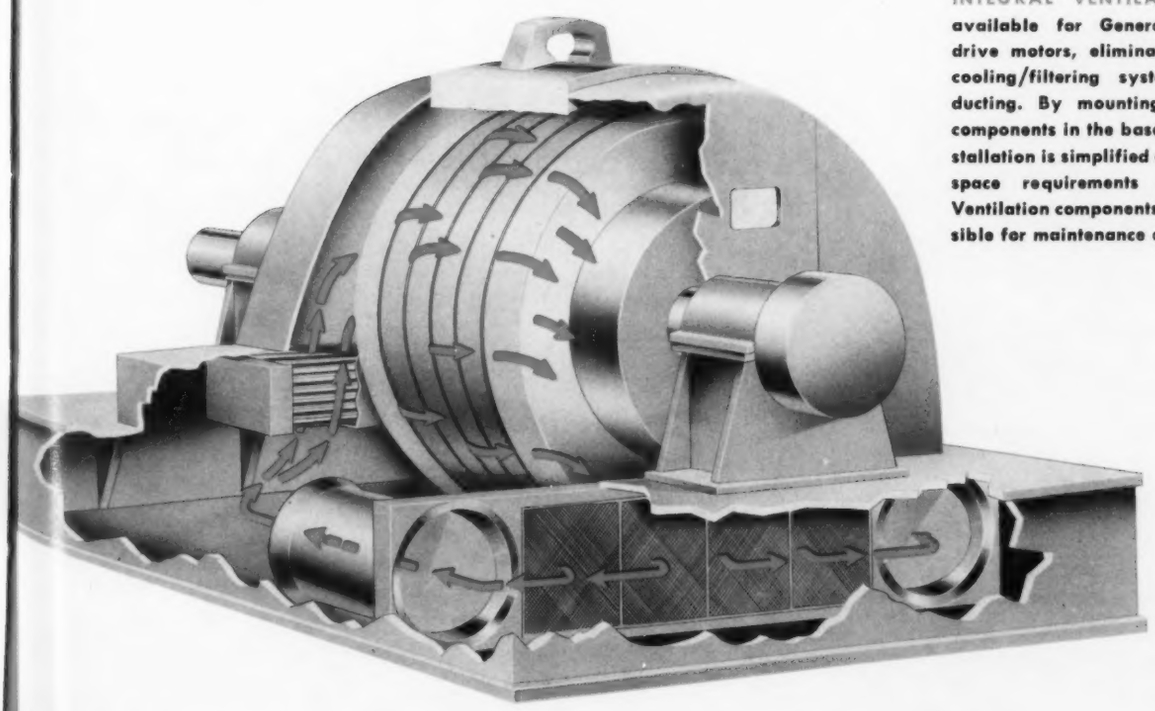
The revolutionary "TOP-FORWARD" twin-drive shown above exemplifies General Electric's continuing emphasis on better design for ease of maintenance. Shaft extension of the rear motor passes *beneath* the forward motor instead of directly over as in conventional designs. This unique drive arrangement allows clear access by overhead crane to all bearings, air-shields and other components of *both motors*.

Shorter over-all length of drive substantially reduces space required and provides cost savings in foundation construction. Improved Class B Insulation system for armatures and fields, utilizing proven resins and compounds, provides greater resistance to heat, moisture and dirt.

Progress Is Our Most Important Product

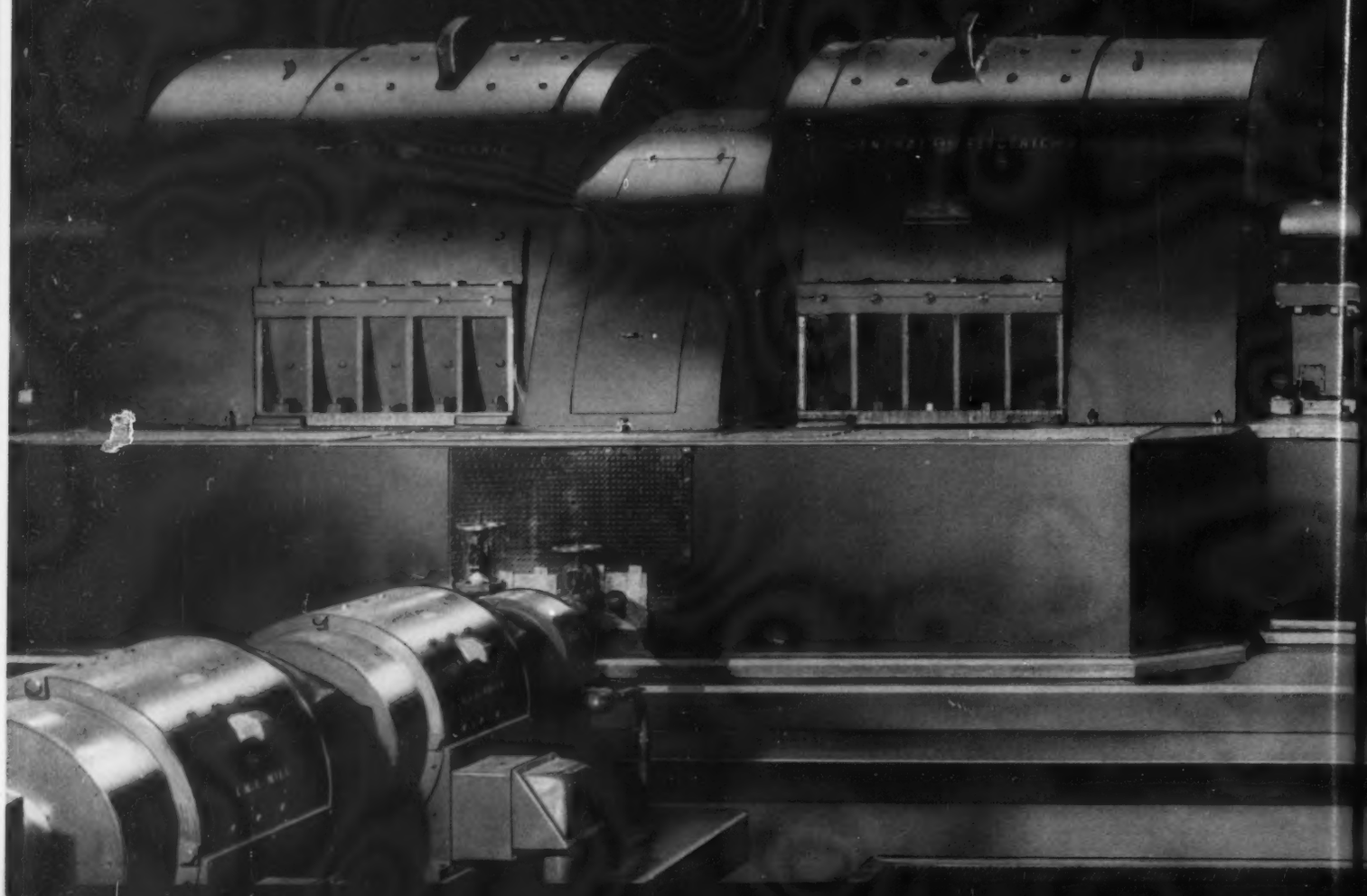
GENERAL ELECTRIC

by New Advances in D-c Drive Design



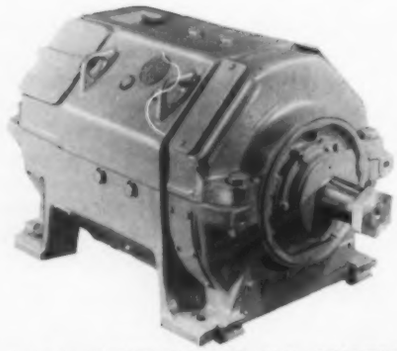
INTEGRAL VENTILATION SYSTEM, **available for General Electric main drive motors, eliminates separate air-cooling/filtering system and related ducting. By mounting all ventilation components in the base of the drive, installation is simplified and supplemental space requirements are eliminated. Ventilation components are easily accessible for maintenance and inspection.**

Three Reasons General Electric D-C Drives are Best for



2. G-E Drives Are Durable and Reliable—

D-c Auxiliary



GENERAL ELECTRIC'S MD-600 ARMORED MOTOR is built to withstand severe shocks, give maximum reliability. Ciass H insulation provides superior protection—permits greater work capacity.

Designed to exceed the requirements of the most advanced continuous processing systems, General Electric MD-600 series armored mill motors are built to withstand regular exposure to hot scale, steam and corrosive sprays. Improved high temperature insulations have appreciably lengthened motor life.

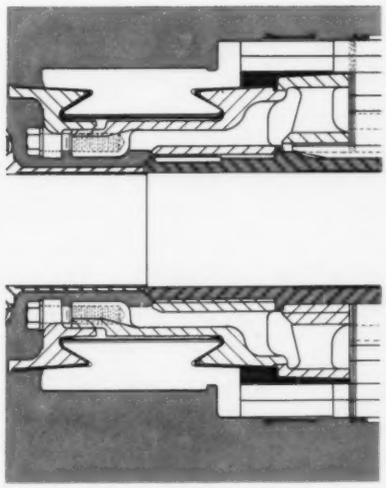
Designed to meet or exceed AISE standards in all respects, General Electric's armored motor offers unmatched flexibility. This motor can be adapted to fit any of five different ventilation requirements simply by adding or removing standard covers. No other modifications are necessary.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Meet Demands of Continuous Processing

DESIGNED FOR EASY ACCESS, top half of General Electric MD-600 motor frame swings open nearly 180° to permit fast armature removal. Positioning keys in frame heads facilitate armature alignment.

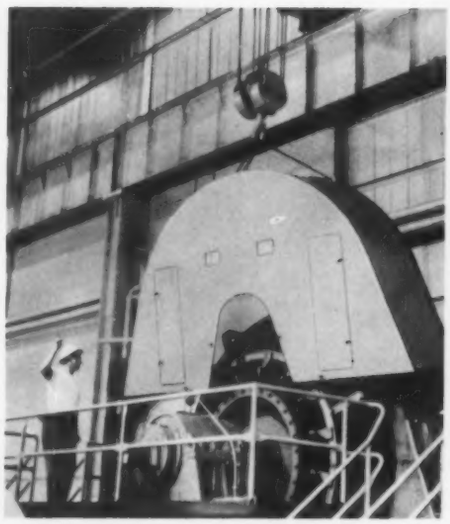


DESIGNED FOR EASE OF MAINTENANCE, the armature on General Electric armored motors is assembled on a steel spider so the shaft can be pressed out without disturbing commutator or windings.

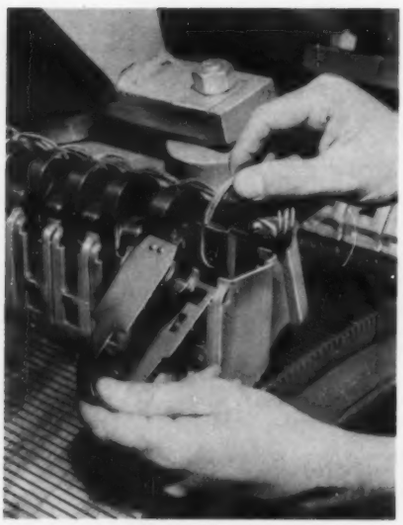
BUILT TO DRIVE HEAVIER LOADS—accelerate, start, stop and reverse faster—MD-600 motors meet toughest demands of automated systems. Integral feet on the endshields allow the armature to stand alone when removed from frame.

Three Reasons General Electric D-C Drives are Best for

3. G-E Drives Give You New Competitive Ad

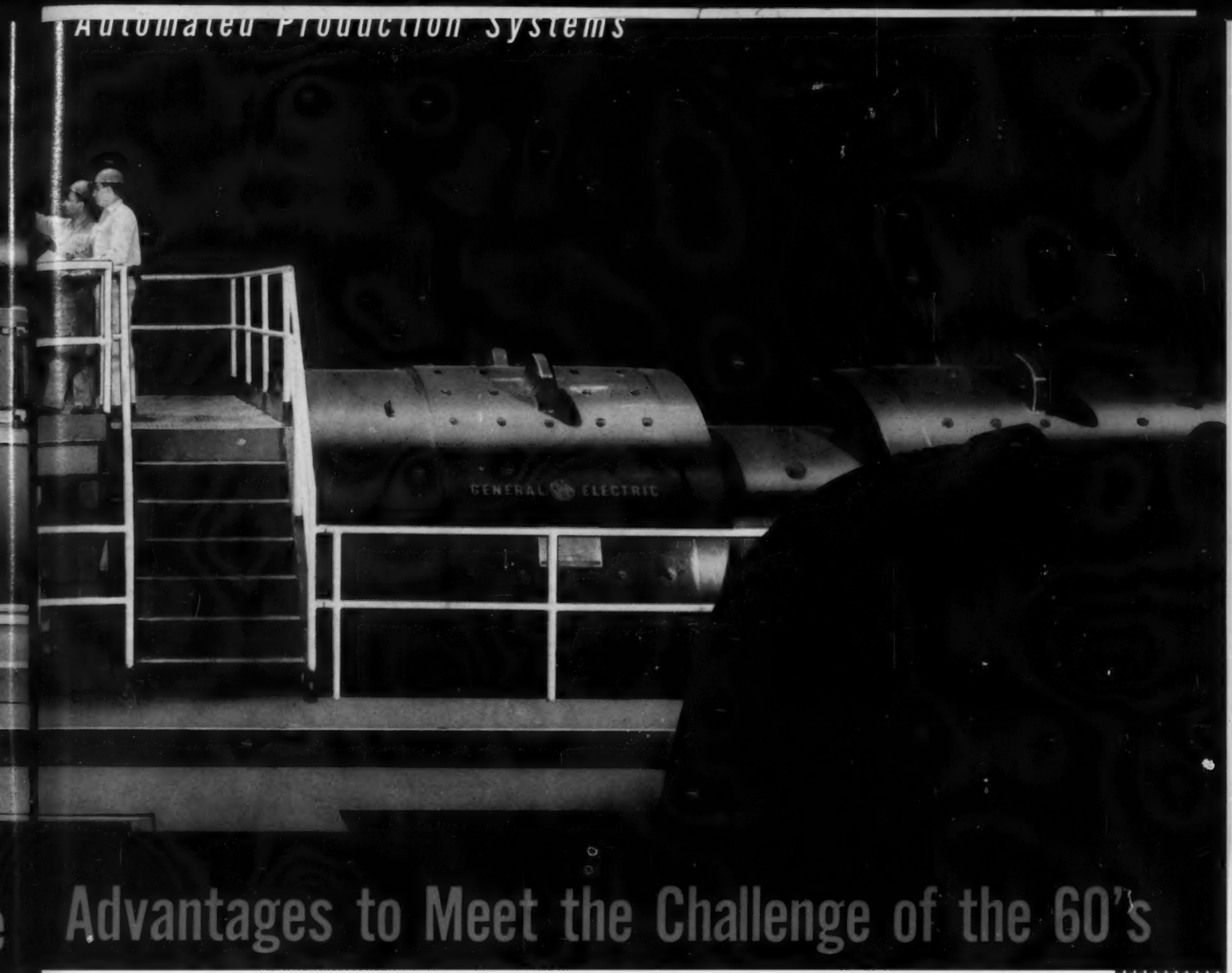


NEW QUICK-REMOVABLE COVERS use no bolts, permit easy access. Tapered guide pins, attached to "TOP-FORWARD" d-c main drive motor frame, accurately position covers on base and frame. Removal and replacement time is reduced to a minimum.



CONSTANT-PRESSURE BRUSH-HOLDERS eliminate all pressure adjustments, give optimum contact at all times. General Electric brush-holder design permits observation of brush wear. Brush can be replaced in seconds.

DISC-LUBRICATED BEARINGS provide positive oiling during all operating conditions. Self-aligning, cast-steel, babbitt-lined bearings can be removed without disconnecting oil piping—maintenance is simplified.



Advantages to Meet the Challenge of the 60's

Higher processing speeds, tighter production schedules and better product quality are requisites of industrial growth in the coming decade. As continuous processing and automation techniques spread throughout industry, rapid maintenance of basic equipment becomes an increasingly important competitive advantage.

General Electric's simplified-maintenance drive design gives you this advantage plus the high thermal and mechanical limits and improved commutation demanded of automated processes.

Let your G-E Sales Engineer show you how easily new d-c main and auxiliary drives can fit into your modernization plans, improve operating efficiency and help you meet the challenge of the '60's. For descriptive information on d-c motors for heavy industry, write Section 772–9, General Electric Co., Schenectady 5, N. Y. *Large Motor & Generator Dept., Schenectady, N. Y./Direct Current Motor & Generator Dept., Erie, Pennsylvania.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

D-c Main & Aux. Drives

NO PLACE TO GAMBLE...

Joints on this water line at steel plant are TAPECOATED to provide protection equivalent to coating on the pipe.

You take no chances when you specify TAPECOAT coal tar coating in handy tape form for pipe, pipe joints, fittings, couplings, tanks, tie rods and conduit on new construction, as illustrated, or for preventive maintenance on replacements.

Since 1941, TAPECOAT has proved its superiority in resisting moisture, acids, alkalis, chemical fumes and other severe corrosive and abrasive conditions.

For example, failure of a water line at an eastern steel plant in 1946 prompted this producer to turn to TAPECOAT for protecting the new line. Results were so conclusive that they have since standardized on TAPECOAT for wrapping fire prevention, water, gas and fuel lines in sizes ranging from 2″ to 48″.

TAPECOAT comes in rolls of 2″, 3″, 4″, 6″, 18″ and 24″ widths. It is easy to apply with the use of a torch. No skilled help required.

A TAPECOAT sales and service engineer is always available to help you on any corrosion problem. Write for details today.

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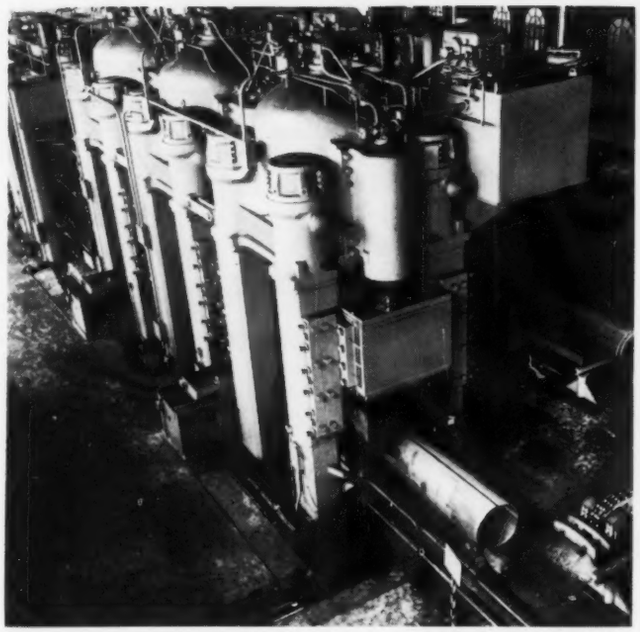


Figure 3 — U-shaped plate moves directly to the 18,000-ton-capacity O-ing press and is precision-spotted by electric eye. A key, mounted at the top of the upper O-ing die and running its full length, prevents the plate from spiraling as the die halves come together. In approximately one minute the "can" emerges, slightly open along the top.

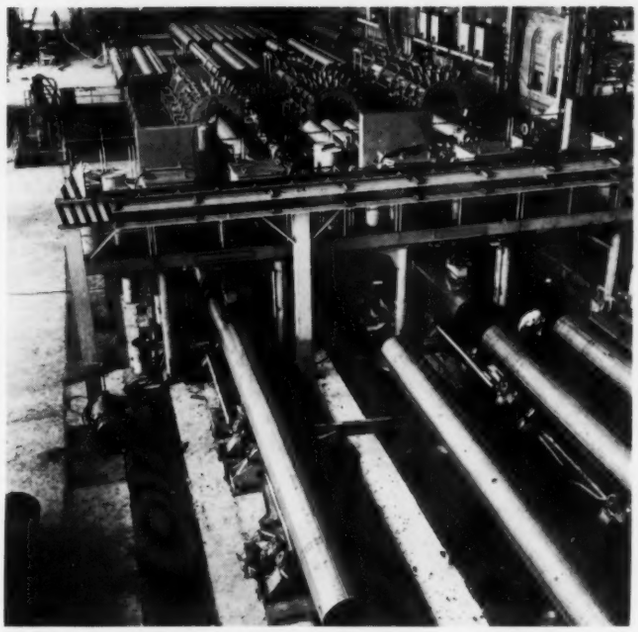


Figure 4 — Cans are moved by conveyors then by gravity skid until they roll into the lead end of one of three cylinder-type inside seam welders. Each can is welded on the inside first at a rate from 50 to 75 in. per min. The outside seam welders (foreground), by tandem submerged electric arc welding, deposit a continuous weld at a rate of 50 to 75 in. per min. Bead is continuous from can to can.

(*Continued from page 194*)

end. Hydraulic squaring devices on the end planer assure a truly rectangular plate, so essential for a perfect pipe section.

A powered table then feeds this plate to a 2500-ton-capacity hydraulic U-ing press. In about one minute the plate is shaped into a long U, as the male punch presses downward in the center of the plate and the rocker die, below, tilts upward on each side. The plate is precisely positioned by limit switches.

The U-shaped plate moves directly from the U-ing press to the 18,000-ton capacity O-ing press and is precision spotted by electric eye. In fact, the O-ing press contains a total of 14 photoelectric cells which will not allow the press to operate till the preceding plate is ejected, the top die is fully up, and the press, in general, is ready to receive and form the next plate. A key, mounted at the top of the upper O-ing die and running its full length, prevents the plate from spiraling as the die halves come together. In about one minute the "can" emerges, 40 ft-5 in. long and slightly open with a one-in. gap running along the top. One man operates both the U-ing and O-ing presses.

The O-shaped can then is placed in prepared pipe storage by cross chains. The can is moved longitudinally by conveyors, then by gravity skid, until it rolls into the back end of one of three inside seam welders. By rotation the gap is positioned at the bottom. The can is welded on the inside first and closed much like a zipper. Slitter rolls vary the gap from about two in. at the extreme back end to zero at the weld point of the leading end.

The inside seam welding unit can handle 18 to 42-in. diameter sizes. It deposits a continuous bead by tandem submerged electric arc welding at a rate from 50 to 75 in. per min. This welder deposits a continuous weld from can to can and virtually eliminates the possibility of making off-track inside seams. The use of retaining rolls prevents cracking while the weld metal is cooling.

The pipe continues its travel, and by gravity skid, is placed on rotators ahead of the outside seam welders. After positioning the seam at the top, the pipe is fed into one of three outside seam welders. Again, by tandem submerged electric arc welding, a continuous weld is deposited at a rate from 50 to 75 in. per min. The bead is continuous from can to can, so it is necessary to break off the weld between pipe sections by tilting one section away from the next.

The next pipe operation—though potentially a bottleneck—is accomplished smoothly through the use of an automatic crane with a built-in memory unit. Pipe sections, coming from three welding units, must enter a common conveyor line. The sections will emerge from the three welders at various intervals and not necessarily in order.

The memory unit stores information coming from the welders and automatically records the order in which it will move from welder to welder to deliver pipe to the conveyor line.

At the pipe inspection station the pipe and weld are visually inspected. Repair stations are provided for grinding inside weld reinforcement at each end repairing weld defects and correcting minor surface defects.

A hydraulic cylinder then raises the pipe onto the expander (max water pressure capacity 5700 psi). This operation enlarges the pipe in circumference (from one to two in.), shortens it in length (about five in.), gives it a higher yield strength, and tests it for bursting strength and leakage. The pipe is enclosed in die clamps and lock bar;

a mechanical plug with rubber gaskets seals off each end. The pipe is then filled with water. Next about 50 gal of high-pressure water is introduced and the pipe enlarges to the limit of the die clamp. This procedure assures a true, circular pipe with each section of equal diameter.

A further test of strength is made while the pipe is still on the expander. After expansion, the pressure is reduced to zero, the lock bar is taken off, the die clamps are lowered, the water pressure is raised to specification test pressure, and then the pipe is struck with several hammers. Time required for the expansion treatment varies from two to five minutes, depending on pipe diameter.

Next, the pipe is fed by conveyor to the fluoroscopic inspection station. The pipe rides a carriage and passes under an operator in a lead-shielded booth. He critically examines the pipe seam continuously at speeds up to 20 fpm. Should he detect a flaw in the weld, he presses a button and a dab of paint is applied next to the defect. The repair station takes care of defects; pipe sections are then gravity fed to the end facing machine.

Here, the ends of each pipe section are beveled, as a lathe rotates around the stationary pipe. This beveling is necessary to permit section-to-section butt welding in field installation.

Final inspection takes place next, with the pipe visually inspected inside and out.

Pipe has then completed its 1000-ft run through the production line and is weighed and measured and loaded out for shipment by rail or truck.

Since this gas transmission pipe is not a shelf item, but instead made to order per the customer's specifications, little storage space is required. Sections are shipped out as made; for example, eleven 36-in. diam pipe sections per rail car, or fourteen 30-in. sections per car. ▲

Tensiometer Regulates Cold Mill Strip Tension

DEVELOPMENT of a new indicating and regulating tensiometer for continuous direct measurement of strip tension in all types of cold rolling mills was announced by Allis-Chalmers Manufacturing Co. The new tensiometer may be applied to mills of any width for accurate measurement of tension over a wide range of strip speeds up to 8000 fpm.

When used with tension regulating circuits, its output is suitable as a feedback signal for direct regulation of the desired rolling tension. Accuracy of tension regulation depends on the system used to control mill drive speed and torque but Allis-Chalmers control engineers now have the necessary accuracy of tension measurement to select a regulating system; to consider the physical characteristics of the material, process requirements and mill design; and to provide a mill control with high accuracy, good transient response and stability under all operating conditions.

The primary design feature of the new tensiometer is the application of the pressductor as the tension measuring transducer. This and the mechanical design used has made it possible to measure tension with no moving parts other than rotation of the tension measuring roll.

Maximum deformation of the tensiometer is only 0.002 in. from minimum to maximum tension thus eliminating the requirement for springs, hydraulic cylinders and pivot points previously used by tension measuring devices.

The accuracy which can be obtained is a direct result of the small tension roll deflection required, since measurement is made by forming a force triangle between the mill roll, a tension roll and a deflector (billy) roll, and translating the vertical component of force (the downward pressure on the pressductors) into an indication of tension according to the hypotenuse of the force triangle. Thus, movement of the tension roll, which changes the force triangle, becomes an inherent error in the tension measuring system.

To further increase accuracy of the system and eliminate errors caused by roll wear and mill pass line changes, several of the tensiometers have been furnished with three rolls. The additional billy roll provides a constant force triangle regardless of mill conditions. The third roll is an exact duplicate of the other billy roll and the tension roll. This further simplifies maintenance because of interchangeability of parts. Several arrangements of standard parts are available to meet almost any particular mounting and arrangement.

The pressductor provides a highly accurate electrical output with low power consumption. Even though its power requirements are low its output will operate indicating instruments without amplification. Electrical balancing equipment consisting of static devices such as transformers, rectifiers and resistors convert and calibrate the electrical signal as required to drive an indicating instrument or tension regulating circuits. Calibrations for individual pressductor adjustment, for tare weight and prestressing loads are simple to make and are seldom required after the initial installation.

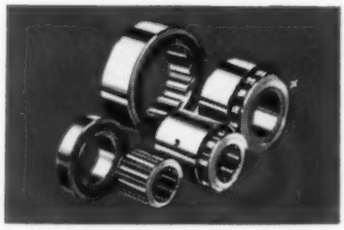
Eleven of the newly developed tensiometers are to be installed on temper mills, sendzimir mills and tandem mills. Most of the designs are for use with tension regulating control which improves mill performance by increased accuracy of tension control despite changes in material characteristic and drive losses, by eliminating inertia compensation during acceleration and deceleration of the mill, and by maintaining stall tension directly. ▲

CARRY THAT LOAD with HYATTS !

Where the crane rolls over and the giant bucket delivers its molten payload, there has to be a roller bearing with muscle and the highest radial load capacity.

For years, the steel industry has called first on HYATT Hy-Roll Bearings to carry that load.

The Hyatt three-part separable bearing provides maximum resistance to shock, abrasion and fatigue—and it can provide radial capacity for heaviest loads. From small bearings for lawn mowers to heavy-duty types used in giant industrial cranes, HYATT builds bearings to carry any kind of radial load.



See your Hyatt sales engineer for just the right bearing recommendation for your application. Hyatt Bearings Division, General Motors Corporation, Harrison, N.J.; Pittsburgh; Detroit; Chicago; Oakland, California.

THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

HYATT HY-ROLL BEARINGS FOR THE STEEL INDUSTRY

GM GENERAL MOTORS

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY

OWNER: *Public Service Company of Colorado*
ARCHITECTS: *G. Meredith Musick & Clayton C. Musick*
ELECTRICAL CONSULTANTS: *Swanson — Rink & Associates*
ELECTRICAL CONTRACTOR: *Howard Electric Co.*
TOTAL FLOOR AREA: *77,400 square feet.*

Electrical Protection goes MODERN *with* BUSS Fuses...

in the New Service Center of the Public Service Co., of Colorado

This recently completed service center, — located at 2701 West 7th Ave., in Denver, Colorado — has fuses installed throughout the entire electrical system.

The primary voltage at the underground transformer vault is 13,800 volts, 3 phase, 4 wire. Secondary voltage is 120 and 208 — 3 phase, 4 wire.

Installed in the main service entrance are BUSS Hi-Cap fuses; the sub-feeders are equipped with FUSETRON dual-element fuses and the lighting panels are protected by BUSS Fustat fuses.

Modern electrical protection calls for fuses because — fuses cannot be equalled by any other type of protective device for their combined high interrupting capacity, lifetime dependability and maintenance-free features.

1160

THERE'S A BUSS OR FUSETRON FUSE FOR EVERY ELECTRICAL NEED . . .

ALL LIGHTING DISTRIBUTION PANELS AND HEATING PANELS PROTECTED BY BUSS FUSTAT FUSES.

MAIN POWER PANELS PROTECTED BY 2,500 AMPERE BUSS HI-CAP FUSES
MAIN LIGHTING PANEL PROTECTED by 1,500 AMPERE BUSS HI-CAP FUSES.

ALL POWER DISTRIBUTION PANELS PROTECTED BY FUSETRON DUAL-ELEMENT FUSES.

TODAY'S INCREASED POWER REQUIREMENTS EMPHASIZE THE ADVANTAGES OF FUSES

Buss LOW-PEAK fuses;
The revolutionary new protective device

If your installation requires unusually high interrupting capacity and great current limitation plus long time-lag to prevent needless shutdowns, check into Buss LOW-PEAK fuses. Made in N.E.C. sizes from 15 to 600 amperes

Ask for BUSS bulletin LPCS.

With available fault currents reaching 75,000 to 100,000 ampere or more — *safe interruption* of fault currents is essential to guard against ruined equipment, fire hazard and personal injury.

Fusetron dual-element fuses meet todays' demand for safety. They have an interrupting rating of 100,000 ampere rms symmetrical — and for protection of mains or circuits above 600 amperes, BUSS Hi-Cap fuses are designed to safely interrupt 200,000 ampere rms symmetrical.

And fuses remain safe and accurate through the years. They require no expensive maintenance or recalibration — they are always ready to function the instant trouble occurs.

For more information on:

Buss FUSTAT fuses . . . . *write for bulletin SCPS*
Fusetron dual-element fuses . . . *write for bulletin FIS*
BUSS Hi-Cap fuses . . . . . *write for bulletin HCS*

Bussmann Mfg. Division, McGraw-Edison Co. **University at Jefferson, St. Louis 7, Mo.**

Alloy and Carbon Cast Steel Wheels by

FARRELL-CHEEK

While the need for replacement wheels is ever present in any plant, your purchases will be many times further apart if you specify wheels and rollers of famous F85 alloy or F-C carbon electric furnace cast steel.

Crane wheels, typical of Farrell-Cheek circular steel castings, have the rigidity, toughness and hardness of treads and flanges to greatly outperform original equipment or replacement wheels.

CATALOG 24 HAS FULL LINE DESCRIPTIONS, ORDERING DATA AND COMPLETE SPECIFICATIONS. WRITE TODAY...

OUR *Fiftieth* YEAR

FARRELL-CHEEK STEEL CO.

108 LANE STREET, SANDUSKY, OHIO

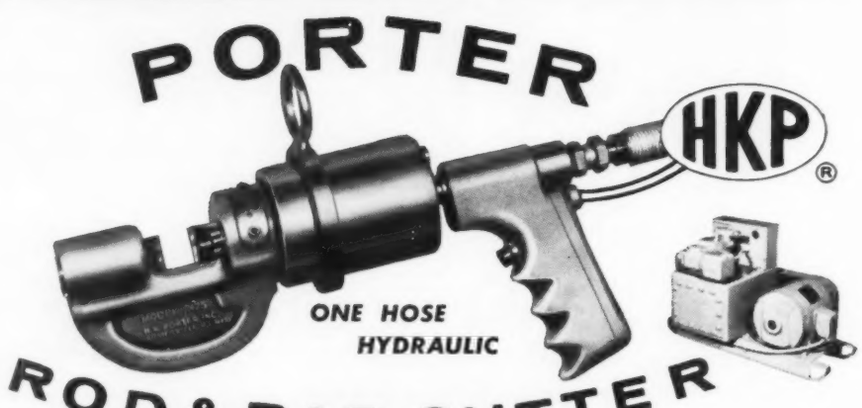
HOW TO CUT HIGH MAINTENANCE COSTS... SPEED CUTTING OPERATIONS

From rod and wire mills everywhere come reports that down-time for repairs is practically non-existent with the Porter Hydraulic. Add to this — *faster* cutting, and you have these vital ingredients for boosting your production. Two features found *only* in Porter Cutters make this efficiency possible.

CUTTER BLADES WITH MORE BEARING SURFACES .... WON'T BREAK DOWN!

Because blades are longer they have more bearing surfaces for *rigid* alignment, thus eliminating any side thrust which causes breakage.

Filtered air taken into the cylinder is forced out around the movable blade on each cut, eliminates danger of dirt reaching bearing surfaces causing oil leakage and wear.



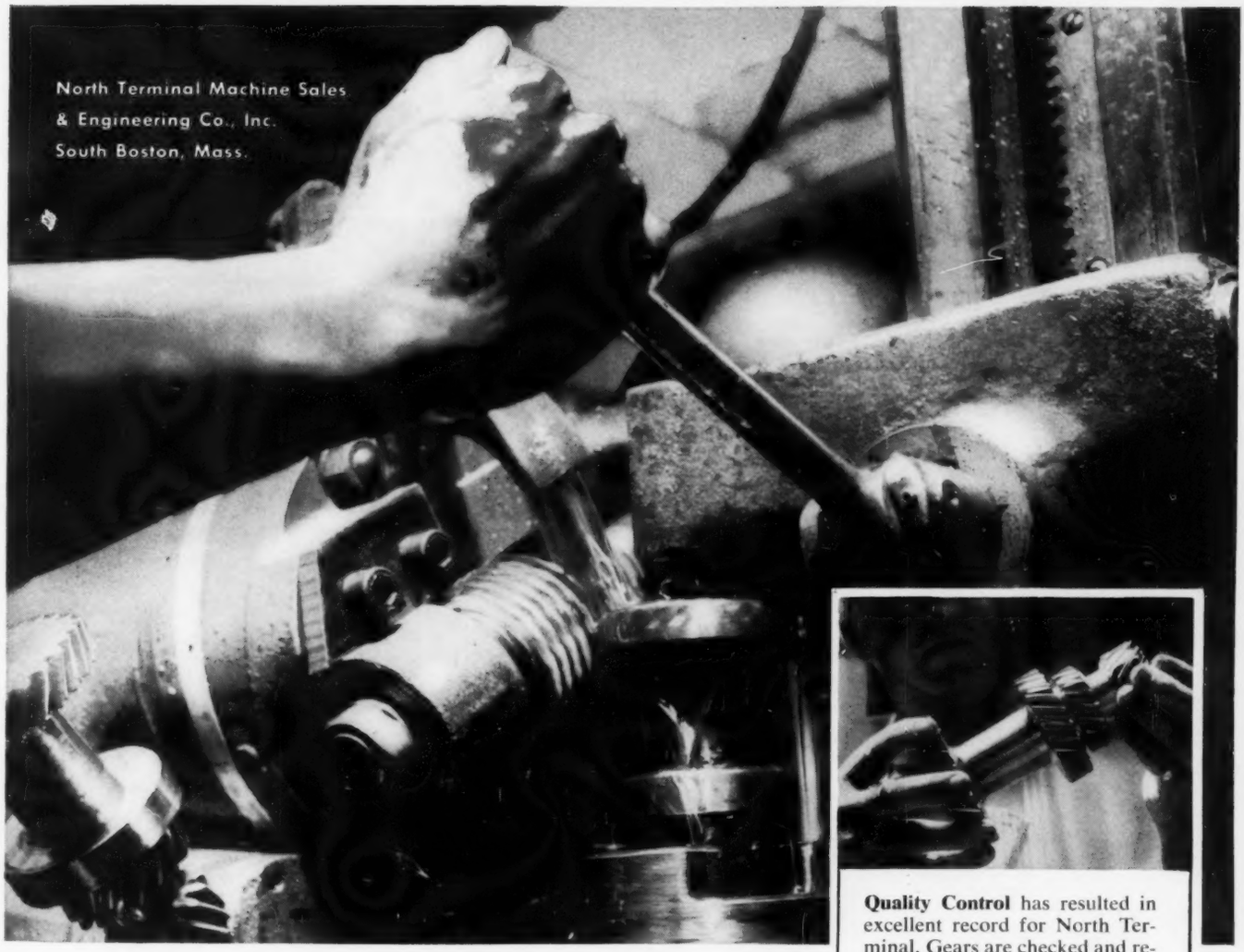
A HYDRAULIC SYSTEM OF FOOL-PROOF DESIGN! One-hose design cuts replacement costs in half. Adjustable relief valve saves wear and tear by providing the correct pressure for any cutting job. Hydraulic oil is filtered by an easy-to-change 40 micron oil filter. And a safe 12-volt control switch on the cutterhead gives instant finger-tip control of the cutting action.

WRITE FOR ON-THE-JOB DEMONSTRATION OR ROD AND BAR CUTTER CATALOG

AVAILABLE NOW! 3 CUTTERHEADS with capacities up to 1⅜" steel rods. 5 HYDRAULIC POWER UNITS. Matched to your exact requirements. Specially designed heads for other non-cutting applications, such as punching, crimping, heading, forming.

H. K. PORTER, INC.,

Somerville 43, Mass.



Quality Control has resulted in excellent record for North Terminal. Gears are checked and rechecked after each step in production. Quality lubricants have helped hold to close tolerances.

Hob Life Increased 250% with Cities Service Chillo 10 Cutting Oil

North Terminal makes replacement gears for automobile transmissions. In a day's time the firm—which makes the gears from raw stock to finished product—completes up to 5600 gears. Producing in quantities like this, hob life is an important consideration in *cost* of production as well as *quality* of production.

Previous cutting oils were tested on the gear hobbing machines and they resulted in hobs producing as low as 87 gears before replacement. Cities Service Chillo 10 cutting oil under the same conditions resulted in over 200 gears with a superior finish before a hob replacement was necessary.

Edward W. Malley Jr., President of North Terminal, states, "We didn't choose Cities Service cutting oil blindly. Many competitive oils were tested before we were satisfied that Chillo 10 was superior in every way."

Even if you're satisfied with your present cutting oil, a test of Cities Service Chillo 10 may give you a very pleasant surprise. Test after test under actual manufacturing conditions has shown Chillo 10 to give longer tool life and superior finishes.

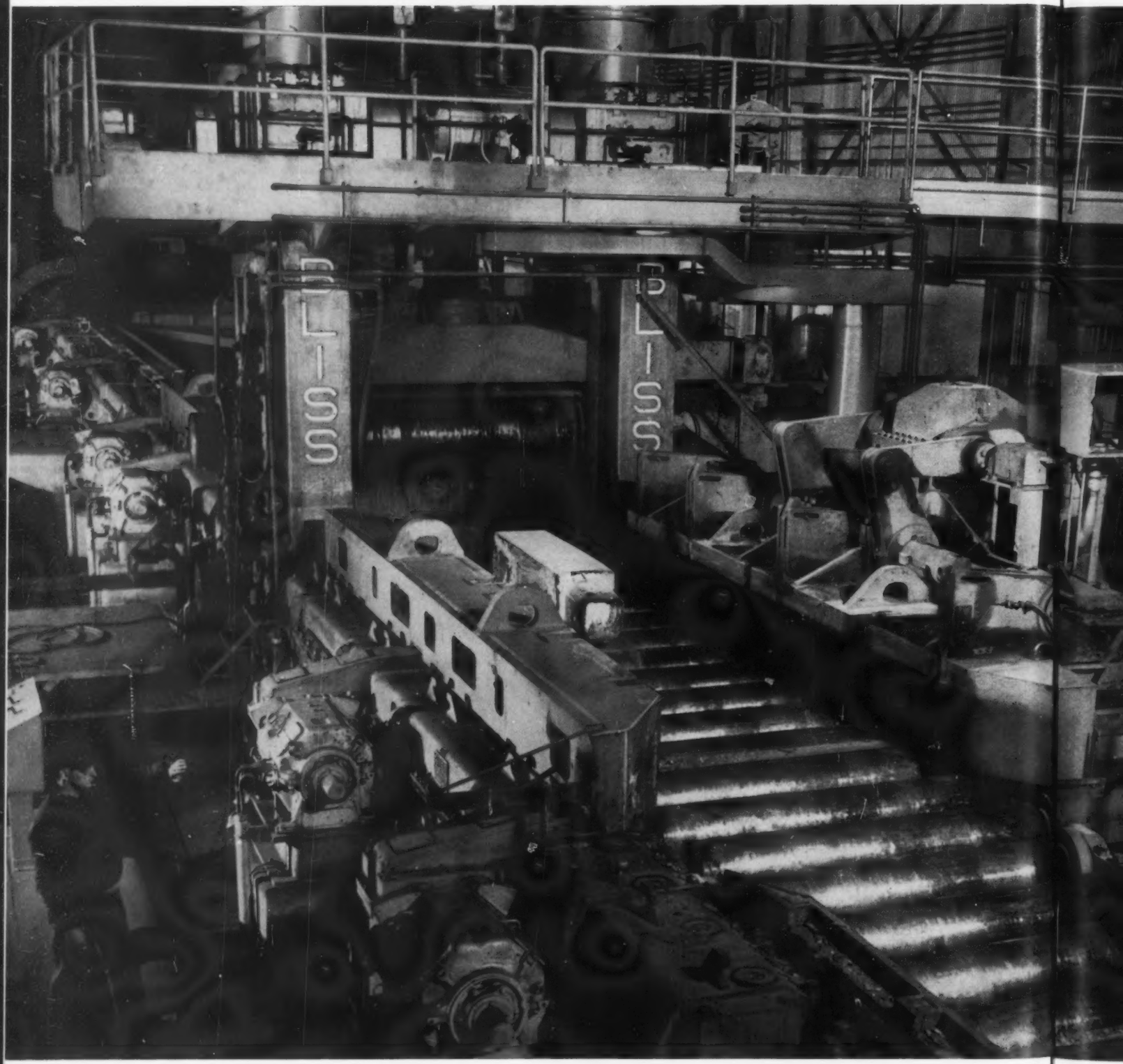
Arrange for your own test by calling your nearest Cities Service office or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, New York.

5600 Gears per day or the equivalent of 800 replaced transmissions are produced every day by North Terminal. Gears are made for all makes of cars with a good portion of production being shipped overseas.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

SLABS, BLOOMS



Hot ingot heads into first pass through new Bliss mill.

AND ROUNDS ON THIS VERSATILE MILL

Quick handling of ingots another dividend

"Big investment, big dividends" sums up the new automated blooming mill illustrated at left. Key component of a new $14 million steel plant, it was built and designed by Bliss' Rolling Mill Division to enable its owner, a prominent manufacturer of heavy equipment, to meet mounting orders for seamless tubing and welding fittings.

Here is automation at its smoothest. With only a handful of men in efficient control pulpits, the plant can turn out blooms of many shapes and sizes.

Heart of the operation is a new, 40″ x 90″ high-lift blooming mill, whose rolls are automatically set for each pass by punched cards. Taking the ingots poured by the new 100-ton electric furnace, it rolls them into the size required.

Of special interest is the mill's unusually versatile design. Thanks to it, the plant is able to handle round shapes as well as blooms and slabs, simply by changing the rolls. The latter were supplied by Bliss' Mackintosh - Hemphill Division.

According to the plant superintendent, this new plant has increased the company's melting and rolling capacity a full 50%. And based on its proven operating performance, the new Bliss mill will be ready to take any additional new load in stride.

Whether your plans call for a big outlay or a modest one, it will pay you to discuss them with Bliss. To learn how other firms have . . . and have profited . . . write for our 84-page Rolling Mill Brochure, Bulletin 40-B.

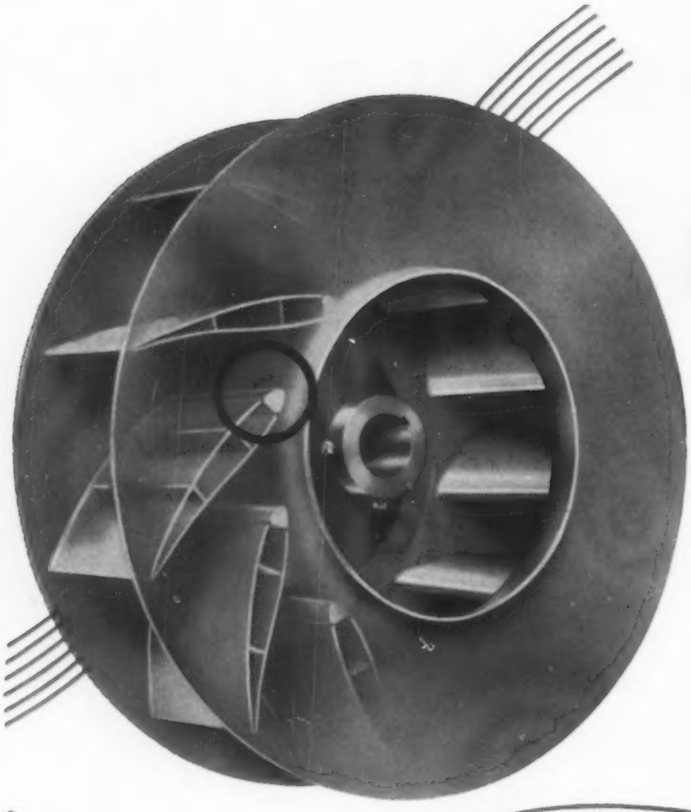
BLISS
SINCE 1857

Bliss is more than a name . . . it's a guarantee

E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Rolling Mills • Mill Auxiliaries • Amerigear / Bliss Spindles

Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio



COSTS HELD DOWN WHEN

® INLAND

INCLUDED

Green Airfoil Fans

IN FURNACE REBUILDING

At their #2 plant in East Chicago, Indiana, Inland Steel completely rebuilt and enlarged their furnaces to increase production. These rebuilt furnaces called for greater induced draft capacity in the waste heat boilers. The old fan installation of 7 Green radial blade fans had been installed 24 years ago.

Inland Steel replaced these 7 Green fans with 7 Green AIRFOIL induced draft fans. No changes were made in the original motors or electrical system. The 7 Green AIRFOIL fans took care of the increased draft requirements without overload on the original 125 hp motors.

In short, the new Green AIRFOIL fans made it possible for Inland Steel to increase the size and capacity of their furnaces without the expense of new motors and electrical installations in addition.

The Green AIRFOIL design provides smooth airflow with a minimum of turbulence. For longer life, the AIRFOIL fan blades have specially designed cast steel nose pieces to reduce wear. (See circled nose piece in illustration.)

If you have a tough job for heavy duty fans, it makes sense to talk over your problem with Green.

Green

THE GREEN FUEL ECONOMIZER CO., INC.,

BEACON 3, NEW YORK

"CLEVELAND"
Billet & Structural
SHEAR BLADES

HILL ACME INDUSTRY

Forty years of experience plus the HILL ACME guarantee of material and workmanship are your assurance of complete reliability and "know how" in producing CLEVELAND Alloy Grade billet and structural shear blades for shearing hot and cold metals.

We are the *only* manufacturers of both shears and shear blades for this application. The advantages of using CLEVELAND blades, produced by a shear manufacturer, are obvious.

THE HILL ACME COMPANY
CLEVELAND KNIFE DIVISION
1203 West 65th Street • Cleveland 2, Ohio

MORE QUALITY ENGINEERED FEATURES IN STEPHENS-ADAMSON
CARRIERS

Series # 200 Carriers

Series #700 Carrier

35° and 45° Deep Trough Carriers

Pneumatic "Impact" Carriers

ADVANTAGES

- Spun-end roller assemblies and parts interchangeable for quick installation.
- One-Piece, all-steel, welded frame construction.
- Positive lubrication . . . pre-lubricated at factory . . . provisions for field lubrication.
- Roller brackets tilt two degrees in direction of travel for greater belt training effect.
- Die-cast labyrinth bearing seals keep grease in . . . dust and dirt out.

S-A
ENGINEERED BULK HANDLING SYSTEMS
MATERIALS HANDLING PRODUCTS
SPEEDWAY PASSENGER CONVEYORS
SEALMASTER BALL BEARING UNITS
SPHERICO BEARINGS & ROD ENDS

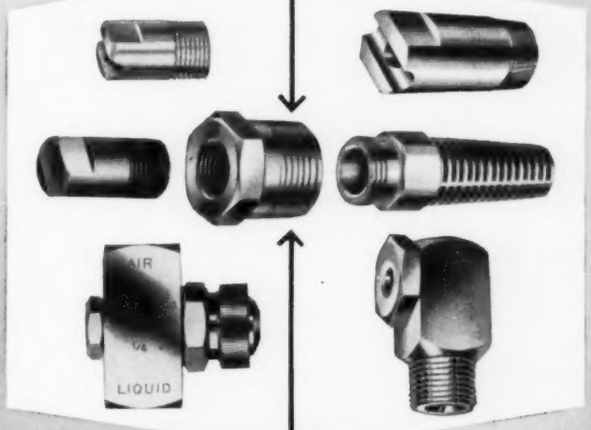
WRITE FOR BULLETIN 355
STANDARD PRODUCTS DIVISION
STEPHENS-ADAMSON MFG. CO.
77 RIDGEWAY AVENUE • AURORA, ILLINOIS
PLANTS LOCATED IN: LOS ANGELES, CALIFORNIA
CLARKSDALE, MISSISSIPPI • BELLEVILLE, ONTARIO

proved
SPRAY NOZZLE
design

TO IMPROVE SUCH SPRAYING OPERATIONS AS

• DESCALING • OXYGEN PROCESS GAS COOLING • PIG—INGOT MOLD—SLAB AND HOT STRIP COOLING • ROLL COOLING • COOLING OPEN HEARTH REGENERATORS • LUBRICANT SPRAYING • BLAST FURNACE GAS WASHING AND COOLING

Whatever the application you will find Spraying Systems Spray Nozzles provide noticeable improvement in spraying operations . . and often materially lower cost. Proved by performance. Supplied in a complete choice of types and capacities for selection of spray characteristics exactly as needed. Your inquiry is cordially invited.



SPRAYING SYSTEMS CO.
3262 Randolph Street • Bellwood, Illinois
For complete information write for Catalog 24 and special data sheet folder "Steel Mill Applications".

Stub at right shows typical waste with conventional cutting carbons; piece at left shows small amount of waste with Kostkutter Rods.

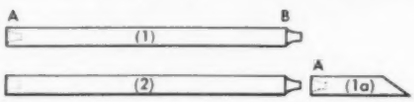
"Speer's new KOSTKUTTER RODS* save us between 18 and 25% over conventional cutting carbons," *says Joseph P. Fucci, General Foreman, Erie Forge & Steel Corporation, Erie, Pa.*

Kostkutter Rods can save *you* money too. Their revolutionary design, a Speer development, allows the joining of the 2½ inches "waste," which would normally be thrown away, to the front of the next rod for further use. Thus, stub loss is virtually eliminated. In addition, Kostkutter Rods make possible further savings by reducing torch damage, since it is no longer necessary to economize by burning carbons close to the clamp. By joining on a new rod, the hot spot can always be kept at a safe distance from the clamping device. The additional "leftover" carbon is used up with the next rod. Kostkutter Rods are copper plated (except the tapered sections) after shaping the rod ends, thus insuring perfect contact between rods.

Kostkutter Rods are available only from Speer. Buy them in diameters of ½", ⅝", ¾" and 1". Standard cutting carbons are also available at slightly lower prices. *Patent applied for

How Kostkutter Rods Save You Money

Each Kostkutter Rod has a tapered hole in one end (A) and a tapered projection at the other end (B) as shown in Diagram 1. The rod is clamped into the torch and used in the normal way. The stub end (Diagram 1a) which, with conventional cutting carbons would be wasted, is removed from the torch and attached to the end of a new Kostkutter Rod (Diagram 2). The tapered end of the new rod slips easily into the tapered hole at the end of the stub and is held firmly by friction. The new rod, with the stub attached, is then clamped into the torch and practically the entire stub is used up instead of being discarded.



SPEER Carbon Co
Carbon Products Division • St. Marys, Pa.

GIANT

SHEAR AND SAW GAUGE

built by Treadwell for strength and stamina

The gauge head is electrically raised and moved, the beam is set over the center of the table, supported by steel offset supports . . . a dependable smooth operation for a rough, tough job. Check the list below for versatile Treadwell production of precision designed equipment.

TREADWELL
ENGINEERING COMPANY · EASTON, PA.

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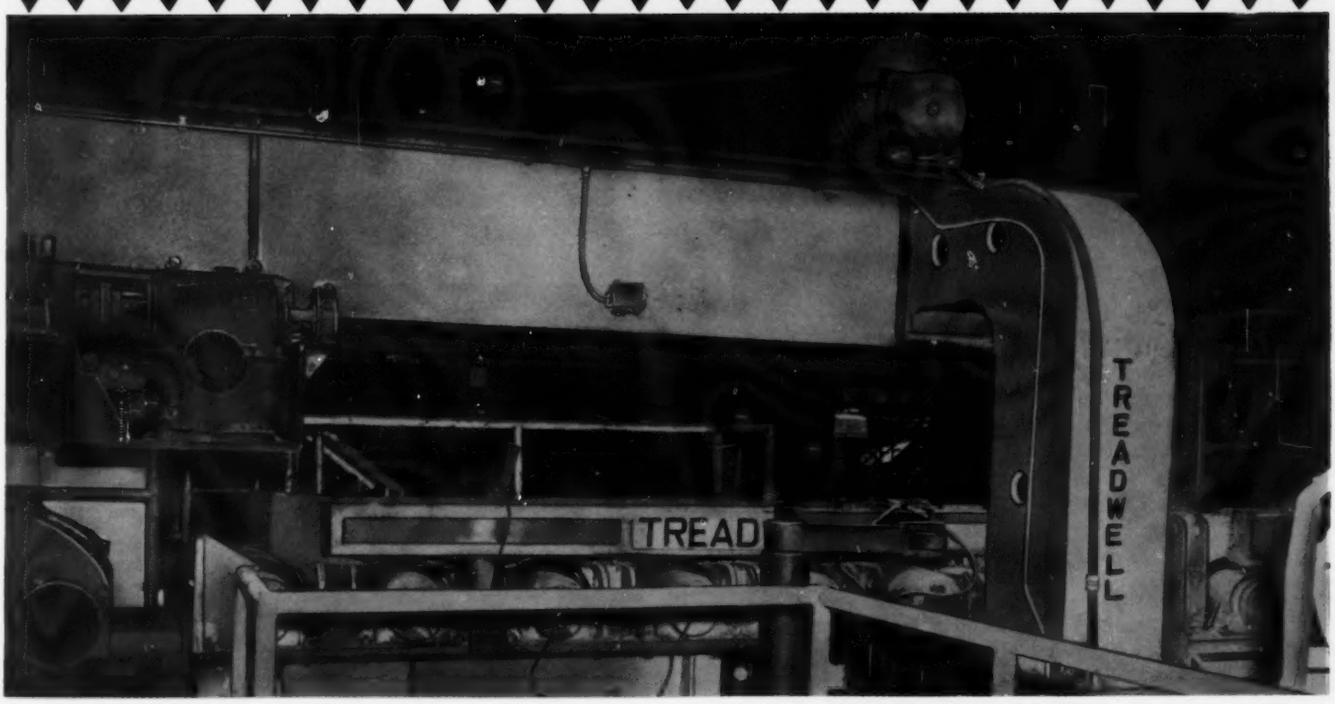
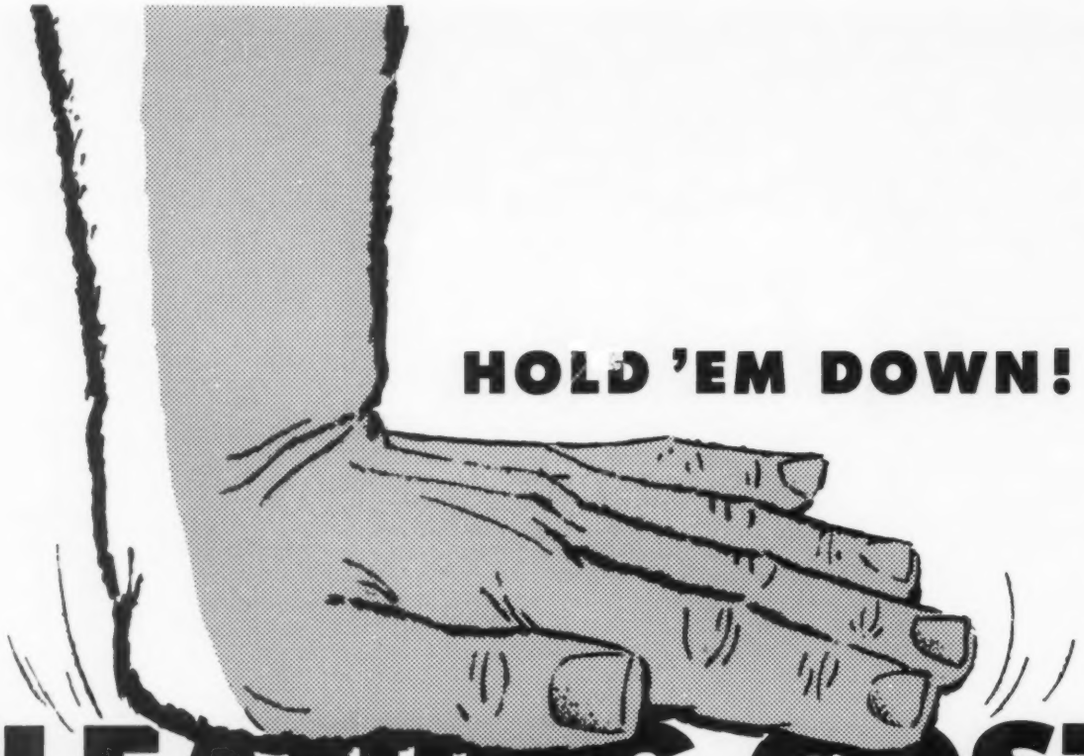
STEEL MILL EQUIPMENT

Manipulators, Mill, etc.
Mills, Billet, Merchant & Bar
Mills, Rod
Mills, Vertical Edging
Mill Repeaters
Coilers & Reels
Tables, Mill
Tables, Tilting & Lift
Tables, Transfer
Transfers
Conveyors, Coil
Drivers & Pinions
Ejectors, Furnace
Gauges, Shear, Saw, etc.
Beds, Cooling
Beds, Inspection
Bumpers, Furnace
Pushers, Furnace
Handling Equipment (Kick-offs, Pilers, Cradles, etc.)

SPECIAL MACHINERY

CASTINGS — Electric Furnace Steel, Ductile Iron, Gray Iron and Ni-Hard





HOLD 'EM DOWN!

CLEANING COSTS

Now, there's a *new* and *dependable* way to reduce cleaning costs — without sacrificing cleaning efficiency! For METAL BLAST has an entirely new and more economical process* for making steel abrasives — and passes the savings along to consumers.

Now, you can make substantial savings on cleaning or descaling costs simply by changing over to "SUPER-STEEL" steel shot and grit. At $165.00 per ton, you'll really save money! And, you'll still enjoy fast and thorough cleaning, low abrasive consumption and low maintenance costs. As a matter of fact, "SUPER-STEEL" is *guaranteed* to equal the performance of any other steel abrasive.

Consider what you're now paying for steel abrasives — probably upwards of $200.00 per ton! Why pay this high price, when new "SUPER-STEEL" costs so much less? Why not check this new, economical abrasive? Write, wire or phone collect for test samples.

*PATENTS APPLIED FOR

METAL BLAST, INC.

876 EAST 67th STREET • CLEVELAND 3, OHIO

Phone: EXpress 1-4274

ALSO IN: Chattanooga • Chicago • Cincinnati • Dayton • Detroit • Elberton, Ga. Grand Rapids • Greensboro, N. C. • Houston • Los Angeles • Louisville Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh and St. Louis.

MANUFACTURERS, ALSO, OF TOP QUALITY "SEMI-STEEL" SHOT AND GRIT, MALLEABLE AND CHILLED SHOT AND GRIT — AT COMPARABLE SAVINGS!

"SUPER-STEEL"

STEEL SHOT *and* GRIT

$165.00 *per ton in truck loads*

Date-line Diary...

November 1

Δ The Bureau of the Census reports that in August, 1960, production of titanium mill products totaled 963,908 lb. compared with 606,238 lb in July, 1960, and 295,325 lb in August, 1959.

November 2

Δ Auto assemblies in October, 1960, totaled 617,816 cars, compared with 507,519 built in October, 1959.

November 3

Δ Sterling area gold and convertible currency reserves in October, 1960, increased $30,800,000, despite $98,000,000 repayment of international debt, ascribed almost entirely to a heavy flow of funds into Britain due to higher interest rates than those prevailing in New York and most other financial centers.

Δ Chicago scrap prices decreased $1.00 to $2.00 a ton; sales of key grade No. 1 heavy melting steel at $28.00; showed a decrease of $1 a ton off last week.

Δ Superior Steel Div. of Copperweld Steel cut prices 1.2 to 1.8 per cent on two types of copper-clad steel which reflects the decrease of 3¢-a-lb on primary copper.

November 4

Δ The Aluminum Assn. reports shipments of aluminum sheet and plate in September, 1960, totaled 108,738,000 lb compared with 114,784,000 lb in August, 1960; shipments of aluminum foil in September, 1960, totaled 20,857,552 lb compared with 20,719,831 lb in August, 1960.

Δ American Iron Ore Assn. reports that shipments of iron ore down the Great Lakes in October, 1960, totaled 7,013,603 gross tons compared with 1,096,450 tons in October, 1959.

Δ Joint report from American Iron Ore Assn. and AISI indicates that receipts of iron ore and iron ore agglomerates in the U. S. for the quarter ended September 30 totaled 40,647,714 gross tons compared with 16,548,110 gross tons in the third quarter of 1959. Stocks on hand as of September 30, 1960, totaled 74,129,653 gross tons, compared with 60,552,579 tons on the same date in 1959; consumption in these same quarters totaled 20,099,049 tons in 1960, compared with 8,605,064 tons in 1959.

Δ The Bureau of Mines reports that production of Pennsylvania anthracite for October, 1960, totaled 1,615,000 net tons compared with 1,518,000 tons in September, 1960, and 1,805,000 tons in October, 1959.

November 7

Δ Dealers delivered 540,200 autos in October, 1960, an increase of 6.5 per cent over October, 1959, sales.

Δ The AISI reports that the operating rate of the steel industry for the week of November 7, is scheduled at 1,464,000 tons (51.4 per cent of capacity). This compares with 1,478,000 tons one week ago (51.9 per cent capacity), and 1,291,000 tons one year ago. Index of production for the week is 91.1.

Δ The AISI reports that shipments of finished steel products in September, 1960, totaled 4,983,228 net tons, compared with 5,071,953 tons in August, 1960, and 1,282,664 tons in September, 1959. For the first nine months shipments in 1960 totaled 57,612,825 net tons compared with 54,939,267 in the same period of 1959.

November 8

Δ The Bureau of Mines reported that consumption of scrap in September, 1960, totaled 4,163,000 gross tons, compared with 4,217,562 tons in August, 1960; pig iron consumed in September, 1960 totaled 3,817,000 gross tons compared with 4,121,556 tons in August, 1960.

Δ The AISI reports that the steel industry's payroll of hourly and salaried workers in September, 1960, totaled $287,182,482, compared with $300,259,708 in August, 1960; total employed totaled 531,111 in September, 1960, compared with 542,668 in August, 1960; payroll cost per hour worked by hourly employees, $3.342 in September, 1960, against $3.313 in August, 1960, not including 45¢ supplemental employee benefits. Average hour per week worked was 34.2 during September, 1960, the same as in August, 1960. For the first nine months of 1960, AISI reports that employment of hourly and salaried employees totaled 595,274 receiving $3,070,539,481; payroll costs averaged $3.359 plus 45¢ per hour average; average hours worked per week was 36.3.

November 11

Δ Pittsburgh Coke & Chemical Co. reported for the quarter ended September 30, 1960, sales totaling $15,068,000, net income amounting to $308,000 equal to 17¢ a share compared with the same quarter of 1959, sales totaling $12,719,000, net income of $291,000 or 16¢ a share. For the nine months ended September 30, 1960, sales totaled $49,738,000, net income $1,423,000 or 95¢ a share; compared with the same period of 1959, sales totaled $50,580,000, net income $2,012,000 or $1.46 a share.

Δ The Labor Dept. reported that unemployment at the end of October 15 increased 191,000 to 3,579,000.

Δ The Commerce Dept. reported that retail sales across the nation in October, 1960, rose to a seasonally-adjusted $18,400,000,000, a two per cent increase over September, 1960, and also was two per cent over October, 1959.

Δ The Commerce Dept. reported that U. S. imports in September, 1960, declined to $1,160,300,000, down $68,000,000 from August, 1960, and down $232,000,000 from September, 1959.

Δ The Bureau of the Census reports that shipments of iron and steel castings in August, 1960, totaled 1,018,997 short tons compared with 942,731 tons in July, 1960, and 905,828 tons in August, 1959.

Δ The Japan Iron & Steel Federation reports that production of ingot steel in September, 1960, totaled 2,054,000 net tons; pig iron 1,078,000 net tons.

November 14

Δ The AISI reports that the operating rate of the steel industry for the week of November 14, is scheduled at 1,464,000 tons (51.4 per cent of capacity). This compares with 1,468,000 tons one week ago (51.5 per cent capacity) and 2,233,000 tons one year ago. Index of production for the week is 91.1.

November 15

Δ Britain's imports exceeded exports in October by $306,000,000; for the first five months in 1960, the deficit averaged $160,000,000.

Δ International Nickel Co. predicted start of operations of its new Thompson, Manitoba project early in

1961 with an annual rated capacity of 75,00,000 lb. This will increase the company's production to 385,000,000 lb annually, compared with Free World total of 550,000,000 to 600,000,000 lb.

Δ The Lake Carriers Assn. reported that iron ore shipment in October totaled 7,855,235 net tons compared with 1,228,024 tons in October, 1959. In the ten months to October 31, ore movement equalled 75,817,321 net tons, up from 42,818,255 tons in 1959.

Δ Alcoa reduced price on aluminum sheet for can manufacture to 32.2¢ from previous charge of 32.5¢.

Δ The Commerce Dept. reported that steel exports in September, 1960, dropped to 226,000 tons, a drop of 102,000 tons from August, 1960, but up 166,000 tons from September, 1959; imports in September, 1960, totaled 207,000 tons, up 23,000 tons from August, 1960, but a decrease of 159,000 tons from September, 1959.

November 17

Δ The Commerce Dept. predicted an increase of 4 per cent in private home building in 1961 to 1,300,000 units compared with an indicated 1,250,000 units in 1960.

November 18

Δ The Commerce Dept. reported that personal income in October, 1960, rose to a seasonally adjusted annual rate of $409,600,000,000 a gain of $800,000,000 over the revised September, 1960, rate.

Δ The Census Bureau reported that private housing starts in October, 1960, rose to a seasonally adjusted annual rate of 1,231,000 units, 15 per cent ahead of September, 1960, rate.

Δ The concensus of purchasing executives at the annual conference of the Railway Progress Institute, predicted that railroad outlays for equipment, roadway and structure in 1961 will decline to $850,000,000 compared with the expected $952,000,000 to be spent in 1960.

Δ Northwestern Steel and Wire Co. reports for the quarter ended October 31, 1960, sales totaled $18,332,759, net income totaled $1,816,140 or $0.73 per share compared with the same period of 1959, sales totaling $630,437, net loss of $1,334,294 equal to $0.54 a share.

Δ The Bureau of the Census reported that shipments of commercial steel forgings in September, 1960, totaled 94,106 short tons compared with 88,318 tons in August, 1960, and 103,487 tons in September, 1959.

November 21

Δ The Bureau of the Census reported that net shipments of aluminum pig and ingot in September, 1960, totaled 105,460,000 lb compared with 161,106,000 lb in August, 1960, and 126,855,000 lb in September, 1959. Shipments of aluminum mill products in September, 1960, totaled 253,111,000 lb compared with 262,036,000 lb in August, 1960, and 262,801,000 lb in September, 1959.

Δ The AISI reports that the operating rate of the steel industry for the week of November 21, is scheduled at 1,352,000 tons (47.5 per cent of capacity). This compares with 1,470,000 tons one week ago (51.6 per cent capacity) and 2,540,000 tons one year ago. Index of production for the week is 84.2.

Δ Babcock & Wilcox Co. reports for the quarter ended September 20, 1960, sales totaled $70,428,000, net profit $4,058,000 or 66¢ a share, compared with sales totaling $68,678,000, net income $2,568,000 or 41¢ a share in the same period of 1959. For 9 months ended September 30, 1960, they report sales totaling $225,417,000, net income of $13,295,000 or $2.15 per share, compared with sales amounting to $242,980,000, net income $12,754,000 or $2.06 share for the same period of 1959.

Δ The Aluminum Assn. reports that production of primary aluminum in October, 1960, totaled 167,015 short tons compared with 162,882 tons in September, 1960, and 173,742 tons in October, 1959.

Δ The ARCI reported that deliveries of new freight cars in October, 1960, totaled 4632 compared with 4265 in September, 1960, and 2284 cars in October, 1959. Orders in October, 1960, totaled 5885, compared with 2061 in September, 1960, and 2722 in October, 1959. Backlog of cars on order as of November 1, 1960, totaled 22,900, compared with 21,662 on October 1, 1960, and 36,199 on November 1, 1959.

November 23

Δ National Machine Tool Builders Assn. reported that new orders for machine tools in October, 1960, totaled $55,950,000, shipments totaled $49,700,000; compared with September, 1960, new orders totaling $52,300,000, shipments totaling $53,950,0000.

November 25

Δ AISC reports that shipments of fabricated structural steel in October, 1960, totaled 313,623 tons compared with 323,516 tons in September, 1960, and 195,313 tons in October, 1959. Bookings in October, 1960, totaled 219,803 tons compared with 259,986 tons in September, 1960, and 244,060 tons in October, 1959. Backlog as of October 31, 1960, amounted to 2,027,776 tons.

November 28

Δ Resistance Welder Manufacturers' Assn. reports that shipments of resistance welding equipment in October, 1960, exceeded $2,000,000; backlogs were reported at better than $8,500,000 on October 31, 1960.

Δ The Labor Dept. reported that living costs in October, 1960, rose 0.4 per cent to a record 127.3 per cent of the 1947–49 average.

Δ F. W. Dodge Corp. reports that construction contracts let in October, 1960, totaled $3,319,145,000 compared with $3,134,500,000 in October, 1959.

Δ The AISI reports that the operating rate of the steel industry for the week of November 28 is scheduled at 1,404,000 tons (49.3 per cent of capacity). This compared with 1,367,000 tons one week ago (48.0 per cent capacity) and 2,650,000 tons one year ago. Index of production for the week is 87.4.

November 29

Δ Weirton Steel Co. announced that production and maintenance employees will receive wage increases ranging from 7 to 13¢ an hour effective December 1, 1960, under terms of the labor agreement between the company and the Independent Steelworkers Union which runs to June 30, 1962.

November 30

Δ Steel scrap prices in Pittsburgh rose 25 to 50¢ a ton from the previous sale a month ago, selling at $29.15 to $29.75 for No. 1 industrial bundles; in Chicago sales ranged from $25.50 to 26.59 a ton, f.o.b., unchanged to off 80¢ from previous sale a month ago.

Δ Labor Dept. figures show an unemployment increase of 193,700 in the week ended November 12; the jobless level in October, 1960, was 3,579,000.

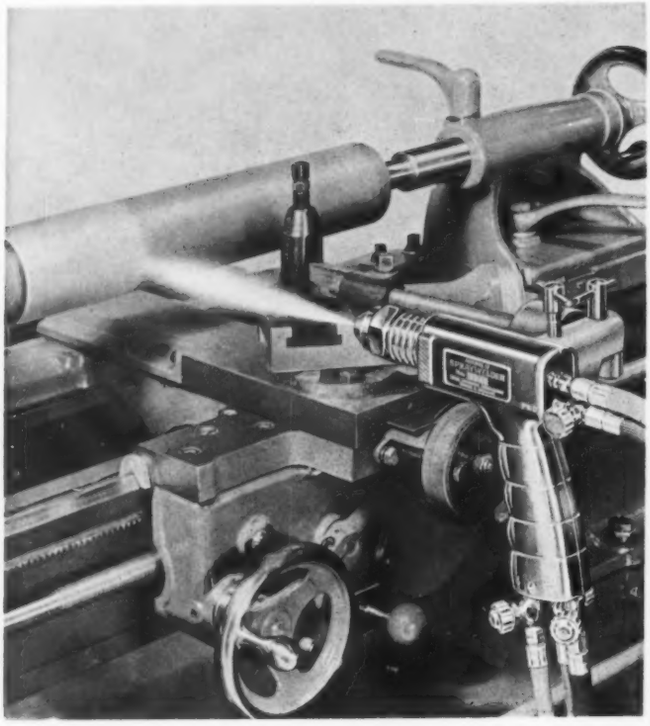
Δ The Commerce Dept. reported that construction outlays in November rose to a seasonally adjusted annual rate of $55,300,000,000, one per cent over the October, 1960, pace.

BLAW-KNOX

Combination Blooming-Slabbing and Plate Mill

Blaw-Knox designed and built this Combination Blooming-Slabbing and Plate Mill, the first of its kind, for The Algoma Steel Corporation. Blaw-Knox equipment for the metals industry includes: Complete rolling mill installations and auxiliary equipment for ferrous and non-ferrous metals · Sheet and strip processing equipment · Electrolytic tinning, annealing, and galvanizing lines · Seamless pipe and tube mills · Draw benches and cold draw equipment · Blaw-Knox Medart cold finishing equipment · Iron, alloy iron and steel rolls · Carbon and alloy steel castings · Fabricated steel plate or cast-weld design weldments · Steel plant equipment · Heat and corrosion resisting alloy castings. Blaw-Knox Company, Foundry and Mill Machinery Division, Blaw-Knox Building, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

Combination 46- x 114-inch Blooming-Slabbing Mill and 38- x 53- x 122-inch 4 high Plate Mill at the Sault Ste. Marie works of The Algoma Steel Corporation.



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How to starve a scrap pile* at its source

*** and all it represents**

(DAMAGED TOOLS, RUINED MACHINES, REJECTS, WASTED LUBRICANTS, UNSCHEDULED DOWNTIME . . .)

TEXACO

Start a "STOP LOSS" program

Bearings ruined before their time by improper lubrication
Downtime caused by a man with the wrong grease gun
Lubricants wasted by over-lubrication
Damaged tools — burned and cratered by using the wrong type of cutting oil
Rejects from faulty cutting and grinding

LUBRICATION IS A MAJOR FACTOR IN COST CONTROL

Texaco's "Stop Loss" program has been developed for progressive managers in production, maintenance, purchasing, engineering and accounting who wish to apply new methods to control costs and add to profits.

The program has two purposes: (1) to demonstrate how organization of lubrication practices can be used to control costs resulting from product rejects, downtime, machine repair, excessive inventory, and (2) to provide specific instruction material to help plant groups find out where and how they can use Organized Lubrication to control costs in their own operations.

Lubrication is common to almost all plant functions. So don't be surprised when the "Stop Loss" program reveals ways to save in many places!

TURN PAGE FOR WHY

Expect tangible results!

HERE'S WHY AND WHERE:

In 1959, hundreds of plants organized their lubrication practices to reduce costs.

Their managements had recognized this fact: *Lubrication is no longer just a routine operating procedure. It is a key factor in controlling costs and, as such, rightly becomes a management function.*

This doesn't mean that management must put on overalls and grab a grease gun. But when management recognizes the dollars-and-cents significance of Organized Lubrication, they have made the first step toward reduced costs throughout the plant.

The Texaco Organized Lubrication Plan studies your lubrication methods in terms of long-range savings in production, equipment life, manhour utilization and inventory. A re-evaluation in terms of Organized Lubrication usually reveals how immediate savings can be made and continued.

Texaco has developed techniques and experience to make this new concept operative. They are offered to you, with the understanding that any Organized Lubrication program depends for success on those who adopt it and apply it.

Here's the help you need to starve YOUR scrap pile

Here are the parts of the Texaco Organized Lubrication Plan available to interested plant groups:

1. "Stop Loss with Organized Lubrication," a new 25-minute color and sound film created to show the opportunities for cost control through "Organized Lubrication."

2. A film "package" for plant departments. This consists of movies on cutting oils, greases, hydraulic oils, etc., that may be selected for showing after seeing the "Stop Loss" film.

3. Coordinated booklets on the film subjects and others to be used as guides in specific areas.

4. A Texaco Lubrication Control System to take the guesswork out of your lubrication scheduling. This simple system costs almost nothing to install, yet can save up to 15 per cent of your maintenance costs.

We can promise you that a modern Texaco Organized Lubrication Program will produce a package of economies in your plant. Texaco Inc., 135 E. 42nd St., N. Y. 17, N. Y.

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Industry News...

GARY SHEET AND TIN TO ADD GALVANIZING LINE

△ A third galvanized steel sheet production line is planned for U. S. Steel's Gary Sheet and Tin Mill, according to T. J. Koenig, general superintendent.

It will be an all-purpose line capable of producing galvanized and aluminum coated steel in widths up to 60 in. and in thicknesses ranging from 14 to 28 gage inclusive, in coils and cut lengths.

The line is being built as a result of a growing demand for galvanized and aluminum coated sheets.

Construction is expected to get under way in the near future. It is scheduled for operation about mid-1962.

CONSTRUCTION BEGINS ON NEW WIRE MILL

△ Work has started on a new 50,000 sq ft plant for Webb Wire Division, The Carpenter Steel Co., at North Brunswick, N. J.

Groundbreaking ceremonies were held November 8 at the new plant site, a six-acre tract located about three miles west of Webb Wire's present location in downtown New Brunswick, N. J.

The plant is scheduled for completion April 1, 1961. It will house a modern wire drawing mill for production of Webb Wire's precision stainless steel spring wire, needle wire and nickel alloy, electrical and low expansion wires.

When completed, the new plant will help double production of some wire products and speed up deliveries for customers. Webb Wire also expects to offer a complete selection of wire coatings to the mechanical spring manufacturing industry.

PLAN NEW EUROPEAN SPECIALTY STEEL FIRM

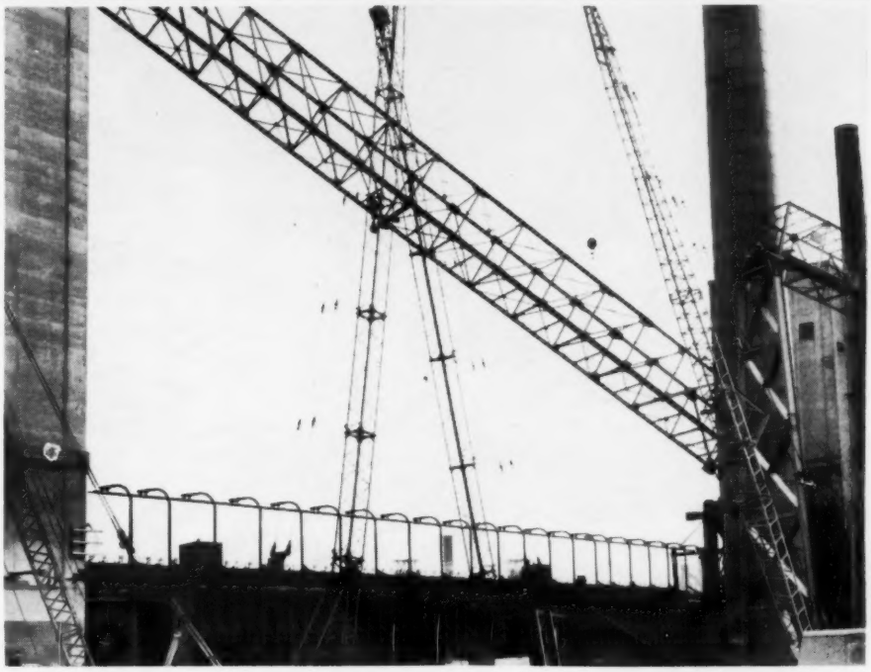
△ Plans for the formation of a major new stainless and special steel company in Western Europe were announced jointly by Allegheny Ludlum Steel Corp., and the Belgian firms, Evence Coppee & Cie, Brussels, and Societe Anonyme Metallurgique d'Esperance - Longdoz, Liege.

E. J. Hanley, president of Allegheny Ludlum, disclosed plans to form a new European company in which Allegheny Ludlum will have equal ownership with the Belgians. The new company will produce and sell stainless and special steels in European and world markets.

The company plans to build a new steel plant in Belgium involving capital investment in excess of $10,000,000. The new plant will have cold-rolling and finishing facilities for supplying flat-rolled stainless and special steel products. Production is expected to begin in 1962.

"Formation of this new company will combine the technical skills of Allegheny Ludlum for producing high-quality stainless and other special metals with the steelmaking talents of Esperance-Longdoz," Mr. Hanley said, adding: "The result will be a strong new force in Europe in the rapidly expanding markets for stainless, high-temperature and other special steels."

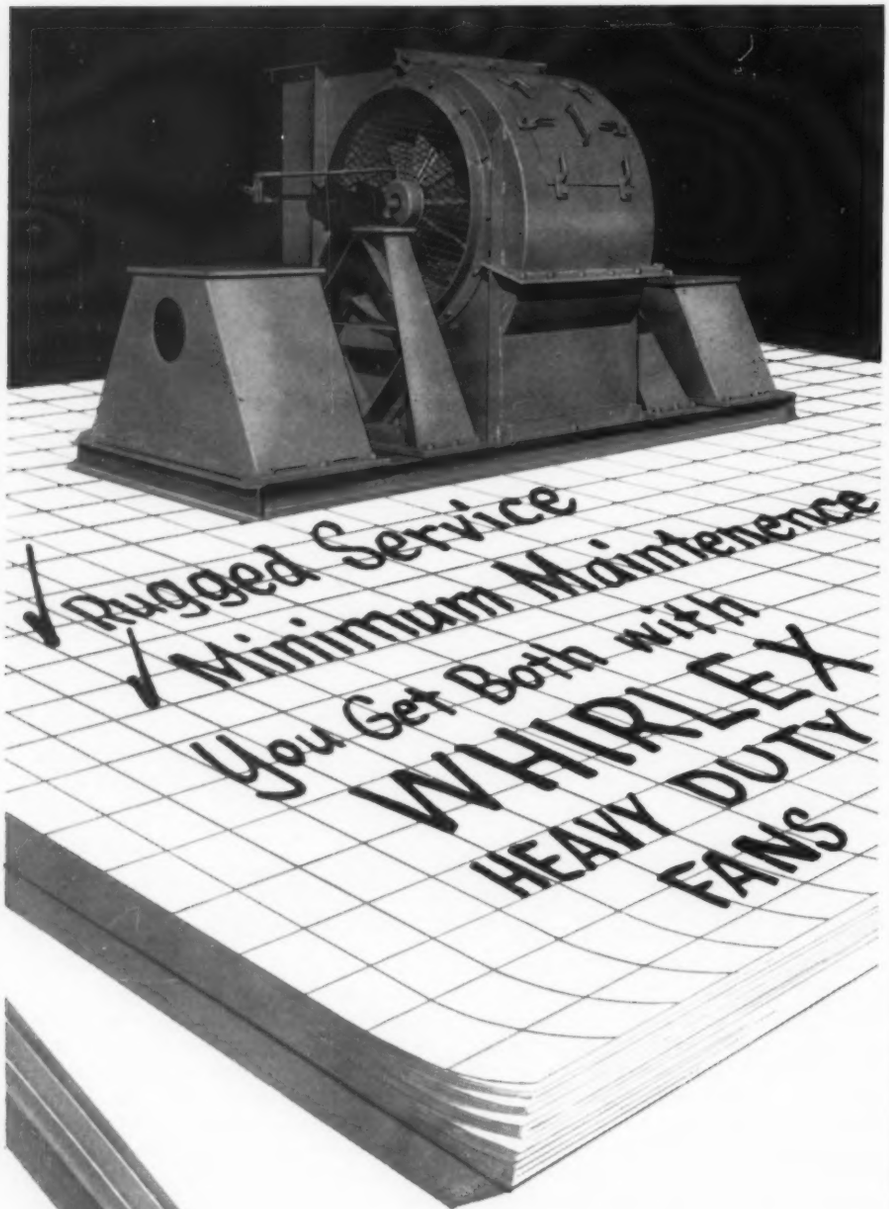
CONVEYOR BRIDGE SPAN MOVED INTO PLACE



A conveyor bridge span 142 ft long and weighing 43 tons is shown being erected by three crawler cranes as part of the new coke oven battery installation at the Lackawanna, N. Y., plant of Bethlehem Steel Co. The lift was made by two 50-ton capacity cranes with 130-ft booms, and one 60-ton capacity crane with a 140-ft boom. The span was set on a slope, with the high end connecting with top of coal bin on left, 140 ft above ground, and the low end on a 100-ft bent which also supports a previously erected section of the span. Through the conveyor bridge will move a 42-in.-wide belt conveying coal from a coal storage area to the coal bin of the new No. 8 coke battery, which will increase the plant's annual coke-making capacity to nearly 3,000,000 tons.

PILOT BLAST FURNACE UNDER CONSTRUCTION

△ United States Steel Corp. is building a small experimental blast furnace which will help to develop a better understanding of the blast



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furnace processes. The new facility is being installed at the corporation's Universal Atlas Cement Division plant, at Universal, Pa.

The experimental unit will further research studies of the chemical changes that occur as raw materials are reduced to iron in the intense heat of a blast furnace. The facility will be operated by personnel from U. S. Steel's Research Center at Monroeville, Pa.

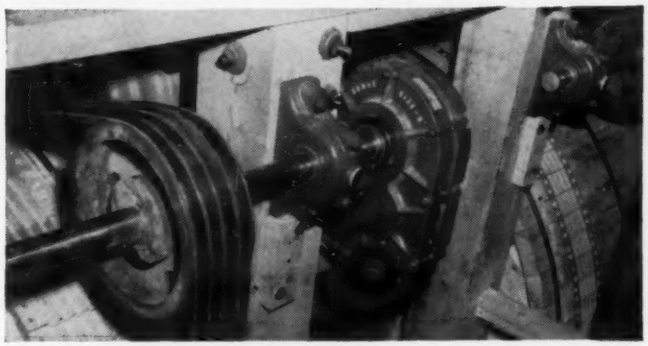
The experimental furnace and its auxiliaries will incorporate many advanced features which will permit the research team to study its interior secrets during operation. It also was designed to operate at much higher pressures than conventional blast furnaces, with blast air in larger volumes and at higher temperatures.

Some of the research tools incorporated in the design of the experimental furnace are fully automatic probes, which can be inserted while the furnace is operating to record gas composition and tem-

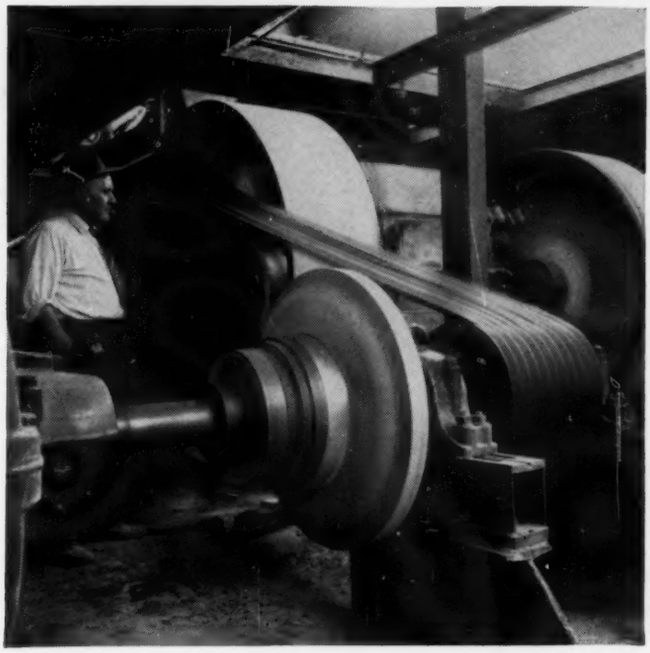
NEW OXYGEN FACILITY

This is the new 500 tons per day on-site oxygen plant, built and operated by Linde Co., Division of Union Carbide Corp., at Great Lakes Steel Corp., Ecorse, Mich. The towering interchanger (background) of the plant consists of a heat exchanger and a fractionating column, where oxygen is separated from the air. In the foreground are a reversing heat exchanger, a nitrogen regenerator, the silencer, the insulation silo and the liquid oxygen storage sphere, which holds the equivalent of 10,000,000 cu ft of oxygen gas.

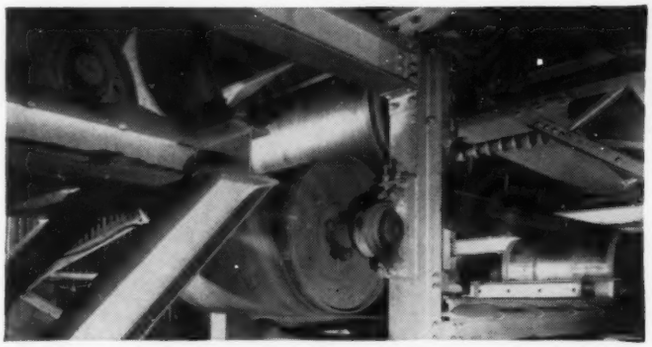
How Dodge pillow blocks with Timken® bearings give longer life with less maintenance



1. Two 2⅞" Dodge Special Duty pillow blocks equipped with Timken® tapered roller bearings, support the line shaft driving six by eight foot tanning drums. The tapered design of Timken bearings enables them to take both radial and thrust loads in any combination.



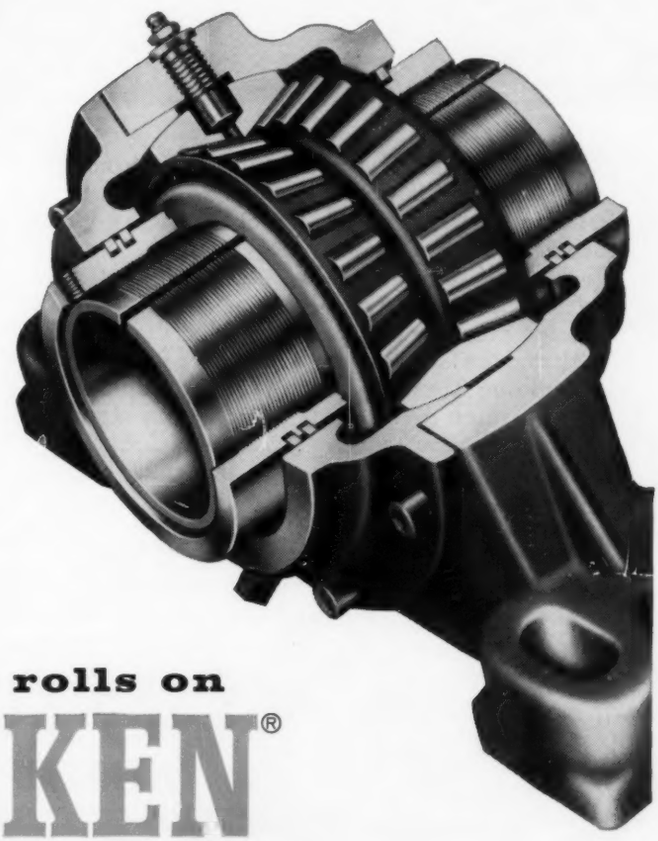
2. The crusher at a trap rock and asphalt plant runs faster, gives more production now that Dodge Double Interlock pillow blocks on Timken bearings are installed. The Timken bearings in these blocks give full-line contact between rollers and races for greater load carrying capacity.



3. The Timken bearings in All-Steel Dodge pillow blocks must stand up under adverse operating conditions found when sintering metals. One major advantage of Timken tapered roller bearings is their ability to hold housings and shafts concentric, thus keeping lubricant in, dirt and dust out.

The photo at right shows the Dodge All-Steel pillow block Timken bearing equipped. The specially designed bearing has a tapered bore with self-aligning spherical outer surface—never needs adjustment.

There's a Dodge pillow block equipped with Timken bearings to fill every engineering need: All-Steel, Type "E", Double-Interlock, Type "C" and Special Duty. And with Timken bearings, space consuming thrust devices are not needed. Look for Timken bearings in all the machines you buy or build. They're the symbol of quality. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ont.



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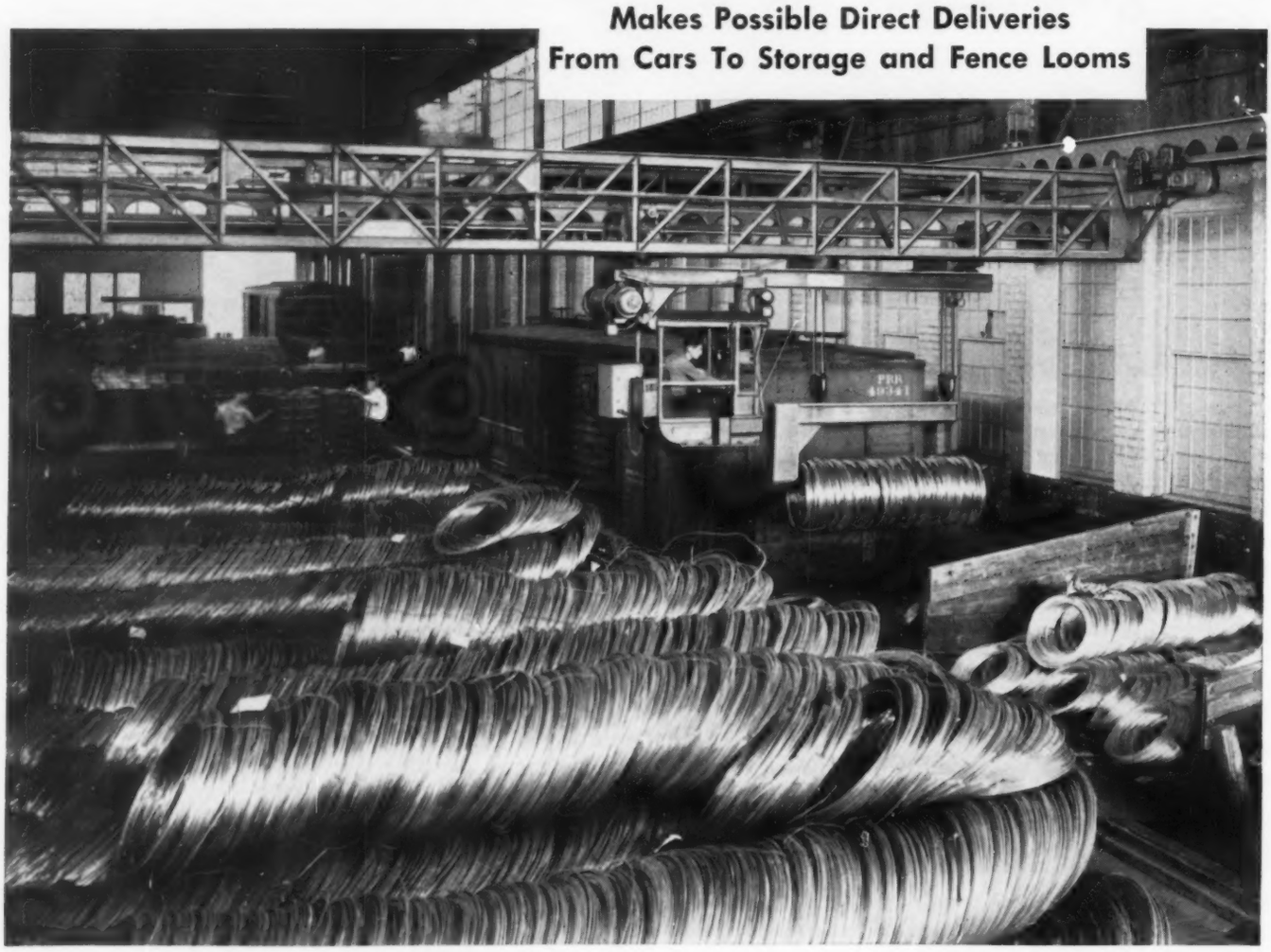

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An important part of the system is a 52'-0" span transfer crane which operates over the railroad track and the large storage area for the full length of the building. The crane is designed with double truss girders which give it great rigidity and strength. This construction has the advantage of light weight and permits interlocking with the track system.

Handling costs are extremely low because the operator in the cab carrier, without floor assistants, can move vast tonnages simply by manipulating controllers in his cab. These permit him to lower, raise and thread the hairpin hook into and out of wire coils, operate the crane on its runway and travel the carrier to all points on the entire track and switch system.

Cleveland Tramrail is playing an important role throughout the wire and rod industry. For any problems on handling, cleaning, drawing, or block-stripping, your inquiries are invited.

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peratures; an infrared analyzer for continuous analysis of top gas; fully automatic equipment in the stockhouse for sizing, weighing and charging raw materials; openings for taking pressure readings over the complete length of the stack, and a complete chemistry laboratory.

Hearth diameter of the experimental furnace will be four feet, and its working height from tuyeres to stockline will be 19 ft 6 in. It is designed to operate at a maximum top pressure of 50 lb, which is considerably higher than the pressure used in operating blast furnaces today.

Other advanced features will be positive displacement blowers which will generate 5000 cu ft of blast air per minute, and stoves which will heat the air to a maximum temperature of 2500 F.

AWARD CONTRACTS FOR BASIC OXYGEN SHOP

△ National Steel Corp. has awarded the general contract for construction of a basic oxygen steelmaking shop with an annual capacity of 2,000,000 ingot tons to The H. K. Ferguson Co., Inc.

The shop will be constructed at the plant of Great Lakes Steel Corp., Detroit subsidiary of National Steel.

Site preparation and alteration of existing buildings to be included in the new shop are underway. Construction will start in the first quarter of 1961 and initial operation is scheduled for the summer of 1962.

Major facilities will consist of two vessels, each of which will have a capacity of 300 tons per heat, the largest ever built. Auxiliary facilities will consist of equipment for charging raw materials and for converting molten steel into ingots. The new shop will be equipped with electrostatic precipitators to clean the gases resulting from steelmaking operations.

CF&I ADDS NEW NAIL FACILITY AT PUEBLO

△ The Colorado Fuel and Iron Corp. has announced the installation of a unique new nail cleaning and magnetic packing line in the Nail

Don't take chances on couplings

CHECK PUBLISHED MISALIGNMENT RATINGS BEFORE YOU BUY

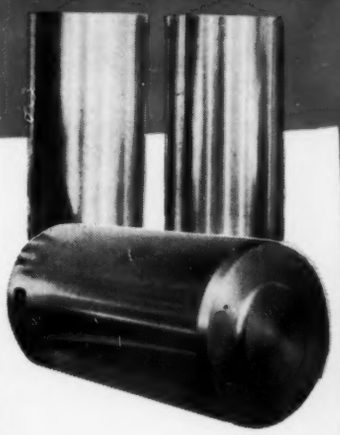
Since misalignment is the basic problem that shaft couplings are designed to solve you'll find a published conservative misalignment rating (along with load capacity rating) for every Fast's Coupling. Compare it with the misalignment rating of any other coupling you are considering.
One further advantage of Fast's Couplings' misalignment ratings: You save money on installation because, knowing the ratings, you don't have to line up driving and driven elements with pinpoint accuracy. It's one more important reason why Fast's Couplings are the choice of more equipment manufacturers than any other gear-type coupling.
KOPPERS COMPANY, INC., 112 Scott Street, Baltimore 3, Md.

KOPPERS

FAST'S COUPLINGS
Engineered Products Sold with Service

RED CIRCLE Rolls ALLOY-CHILLED

Hyde Park RAMS



for all types of HYDRAULIC EQUIPMENT

Hyde Park Rams are available in Chilled or Alloy Iron.
Furnished in hardness range to meet your specification . . . ground to your required size.
On your next replacement of Rams—or for new equipment—consult us. Our engineers will be glad to assist you.

Red Circle Rolls for every Purpose
Rolling Mill Equipment
Gray Iron Castings up to 80,000 lb.

Hyde Park
FOUNDRY and MACHINE CO.
HYDE PARK
Westmoreland County, Pa.
Rolls
Rolling Mill Equipment
Gray Iron Castings

Department at Pueblo, Colo.

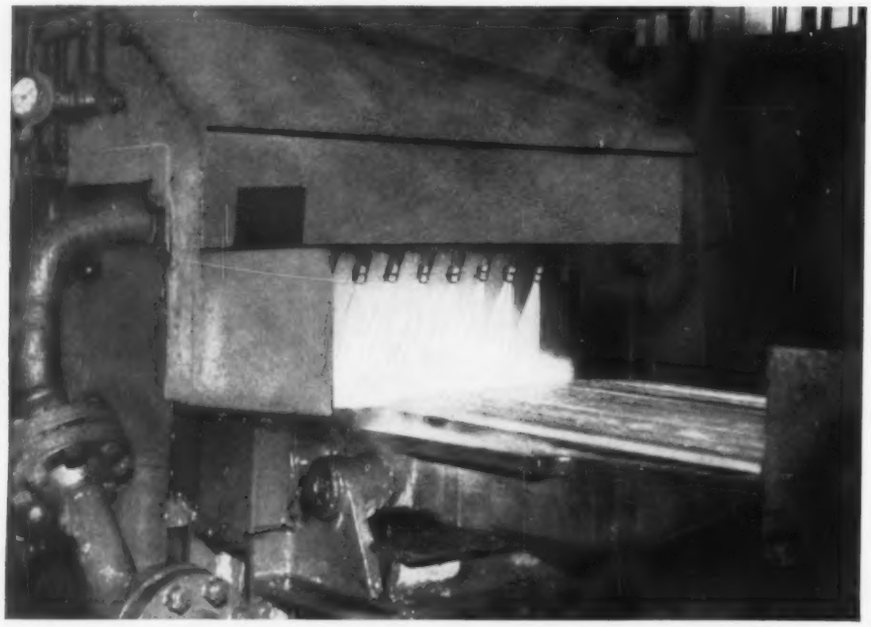
Nails fresh from the cutting machines are dumped into a hopper where they travel upward on a magnetic conveyor to a point some 12 ft above the floor. Here they start their downward trek by falling into a rumbling drum where small pieces of steel are "tumbled" off.

From the drum the nails pass into a bath of tri-chlorethylene wash where grease is removed, and then on to a preset scale. From the scale the nails begin a free fall through a strong electrical field and hang suspended for a moment causing them to line up in a parallel position before the current is reversed.

The demagnetized nails then drop into a new, more compact packing carton.

By combining four steps—dewhiskering, degreasing, weighing and packaging, not only is waste motion greatly removed, but nails are sharper, cleaner and neatly packed.

TITZEL High Pressure DESCALING SYSTEM



FOR REMOVAL OF BOTH HEAVY AND LIGHT SCALE

A modern Titzel Descaling System is positive assurance that you will get enough pressure for the production of clean and scale-free steel. Consult Titzel for a no-obligation discussion of your strictest requirements.

- Stopper Rod Drying Ovens
- Hydraulic Descaling Systems
- Mill Scale Handling Systems
- Palm Oil and Rolling Oil Clarification Systems
- Mill Dust Handling Systems
- Pneumatic and Mechanical Conveyors
- Crushing Installations
- Jib and Casting Pit Cranes
- Hot Topping and Capping Cranes
- Jib, Pillar, Wall and Floor Traveling Cranes
- Cover Cranes for Steel and Aluminum Plants
- Button and Skull Burning Cranes for Scrap Yards
- Designers and Manufacturers of Special Equipment

Since 1928 **TITZEL ENGINEERING, INC.**

260 42ND STREET, PITTSBURGH 1, PA.

ALLIED COMPANY, TITZEL ENGINEERING & EQUIPMENT CO.

SIDE-DUMP RAIL CARS REPLACE HOPPER-TYPE

△ Iron ore is now being transported from storage to stock house by air-operated side-dump railroad cars at The Timken Roller Bearing Co.'s Canton, Ohio, steel mill.

Ore was formerly transported by hopper cars. Walkways or plates approximately two feet wide had to be located by the crane over the scrap bins on each side of the hopper car.

After the hoppers were opened, a crane-operated car shaker was used to finish emptying the car. This was a noisy and time-consuming operation.

With the use of side-dump cars, the dumping operation is more efficient and the preparation for dumping is much simpler. Air lines are attached, valves operated, and the car is dumped.

The problem of "frozen" hopper cars which required extra labor to loosen the ore has been solved. Personnel no longer have to walk over rails, bins or next to cars for unloading purposes.

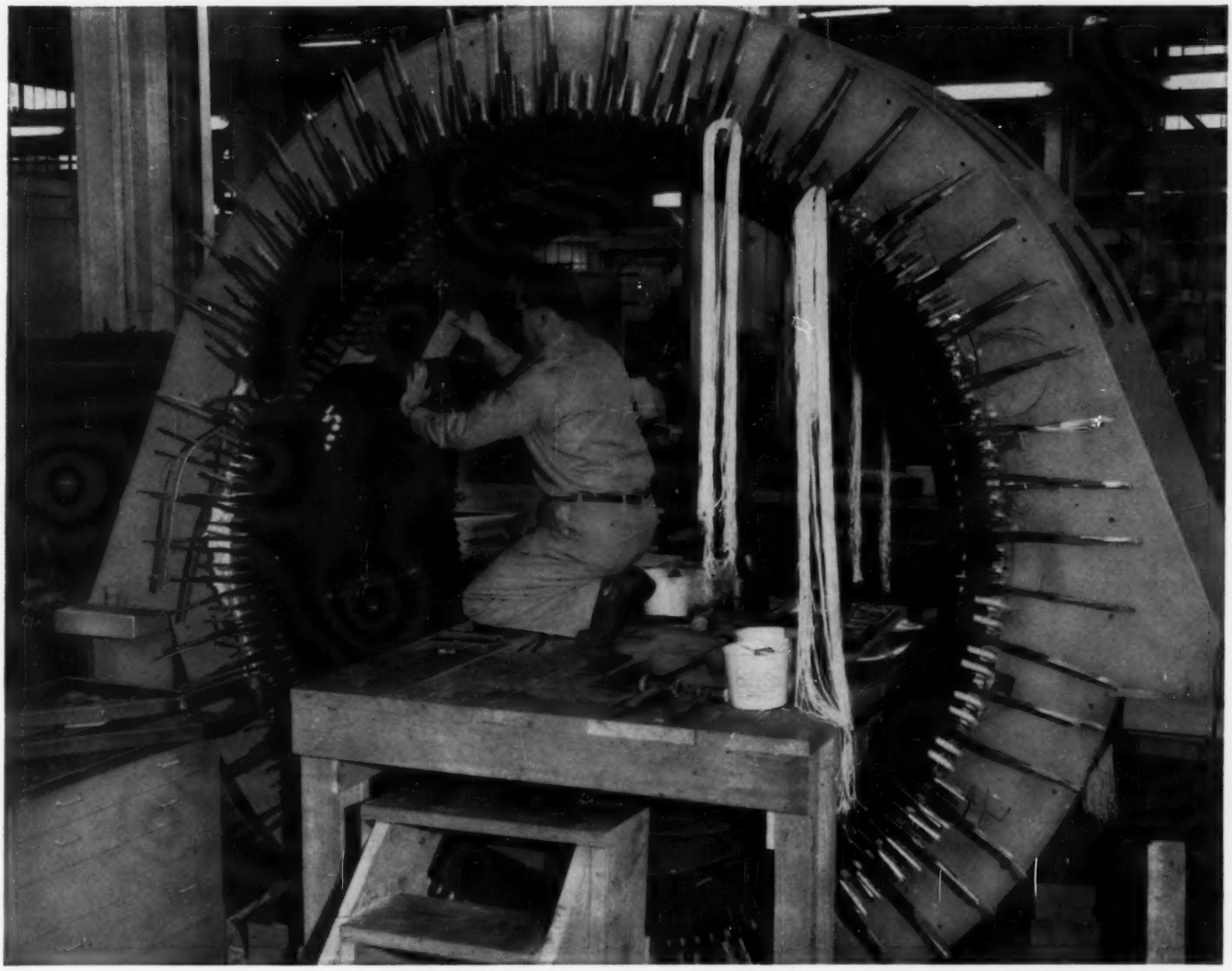
G. E. AWARDED CONTRACT FOR NEW FRENCH MILL

△ Societe Lorraine de Laminage Continu of France has signed a contract valued at over $3,500,000 with International General Electric and Societe Generale de Constructions Electriques et Mecaniques (ALSTHOM) for electrical equipment for one of the most modern and fastest tandem cold rolling mills on the continent.

SOLLAC will install the 6000 fpm mill at its Florange plant near Thionville, France, and it is expected to be in commercial operation early in 1963 to produce high grade steel.

Under the contract, IGE, the overseas marketing organization of General Electric, will supply the main drive motors totalling some 24,000 hp, the main drive control, x-ray gages for continuous checking and automatic correction of steel thickness, and data logging equipment to record thickness as the steel is processed.

ALSTHOM will supply many of the other electrical components including the main motor generator sets and auxiliary drive and control equipment.



Installing NECCOBOND coils in 4000 HP, 400 rpm, 6600-volt stator of mill drive motor.

NECCOBOND insulation system protects motors in severe environments

Completed winding passes 23,000-volt test.

Provides optimum resistance to moisture, heat, corrosive atmospheres

NECCOBOND is specified for rewinding many big rotating machines, like this 6600-volt steel mill motor, that have to perform in rugged environmental conditions.

NECCOBOND is based on time-proven insulating materials—mica and glass. These are welded by a special impregnant into a tenaciously bonded, resilient, voidless insulation wall. A unique method of fabrication assures homogeneous insulation.

When you require rewinding or rebuilding of your heavy duty motors, particularly where moisture, heat, or corrosive atmospheres are encountered, specify NECCOBOND. For information call National's Columbus plant... HUdson 8-1151... or check the nearest National field engineer.

NATIONAL COILS

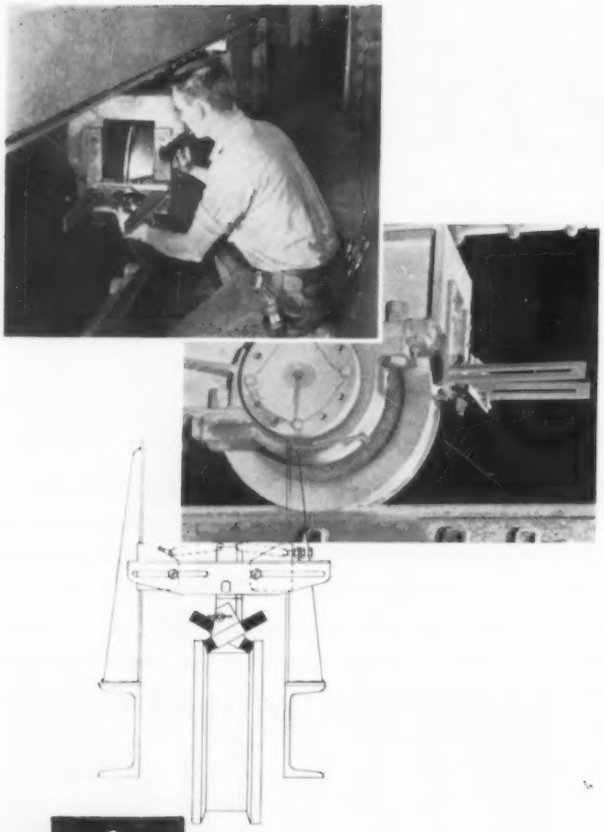
National Electric Coil

COLUMBUS 16, OHIO • IN CANADA: ST. JOHNS, QUEBEC

DIVISION OF McGRAW EDISON

a skilled worker for industry...

RINGSDORFF FLANGE WHEEL DRY LUBRICATION SYSTEM



REDUCES WEAR... CUTS MAINTENANCE AND OPERATING COSTS

Ringsdorff's new dry lubrication method makes it possible to considerably reduce wear and improve running behavior of cranes—therefore cutting down expensive maintenance and operating costs. There is no loss of traction . . . no wear due to accumulation of dust and dirt deposits in the lubricant.

PROLONGED WEAR

In multiple crane installations it is only necessary to equip one wheel on each side of the center crane . . . the film is transferred from flange to rail side to flange. Ringsdorff's Dry Lubrication System prolongs the life of wheels and flanges, decreases maintenance costs and prevents costly "down-time."

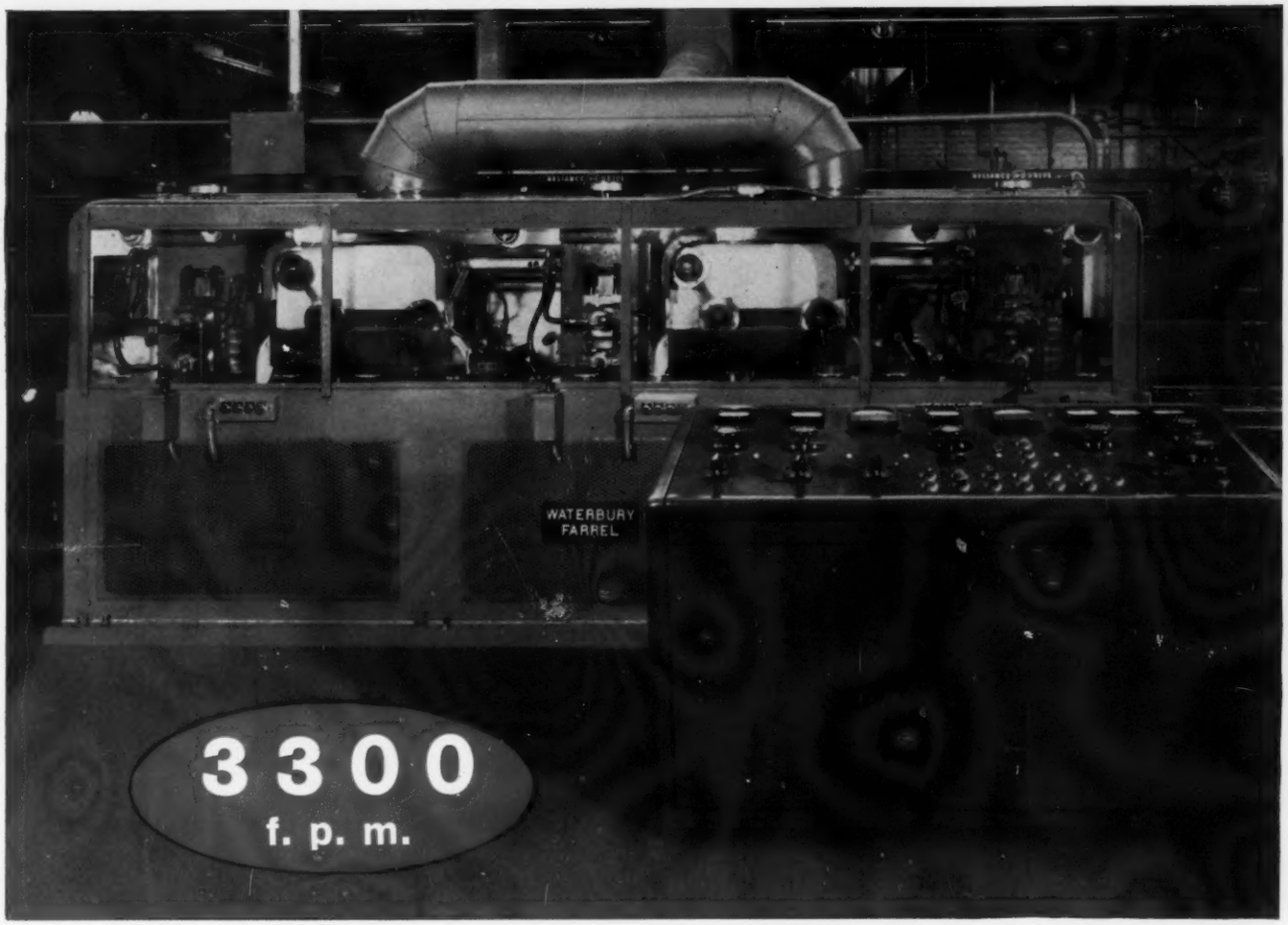
RINGSDORFF "D-4"

Ringsdorff developed graphite, grade "D-4" with lubricating properties inherent in carbon. It forms a smooth, hard lubricating film over wheel flange surfaces . . . does not cause loss of traction. "D-4" is available in rectangular rod form to fit the holding device, which is universally adaptable to fit traveling crane undercarriages.

For specific engineering assistance, contact:

RINGSDORFF CARBON CORPORATION

P.O. BOX 22 · EAST McKEESPORT, PA. · (PITTSBURGH DISTRICT)



PRECISION *Wire Flattening* MILLS

THE WATERBURY FARREL 3-STAND TANDEM WIRE FLATTENING MILL, pictured above, is rolling close tolerance, high carbon steel wire at the Athenia Steel Div., National-Standard Co., Clifton, N. J., *at speeds up to 3300 feet per minute.* Tolerances are being held within 0.002" on width and 0.00025" on thickness of finished rectangular wire. Modern, cabinet type enclosure of the mill and its coolant troughs keeps the installation clean and facilitates the exhausting of fumes and evaporated coolant.

We invite you to contact us for your requirements in rolling mill equipment. In addition to Wire Flattening Mills, we design and build Sendzimir Cold Strip Mills, Two-High and Four-High Mills, Two-High/Four-High Combination Mills, Rod Mills, Special Mills, Gang Slitters, and Accessory and Auxiliary Equipment.

WATERBURY FOUNDED 1851 FARREL

THE WATERBURY FARREL FOUNDRY & MACHINE CO.

DIVISION OF TEXTRON INC.

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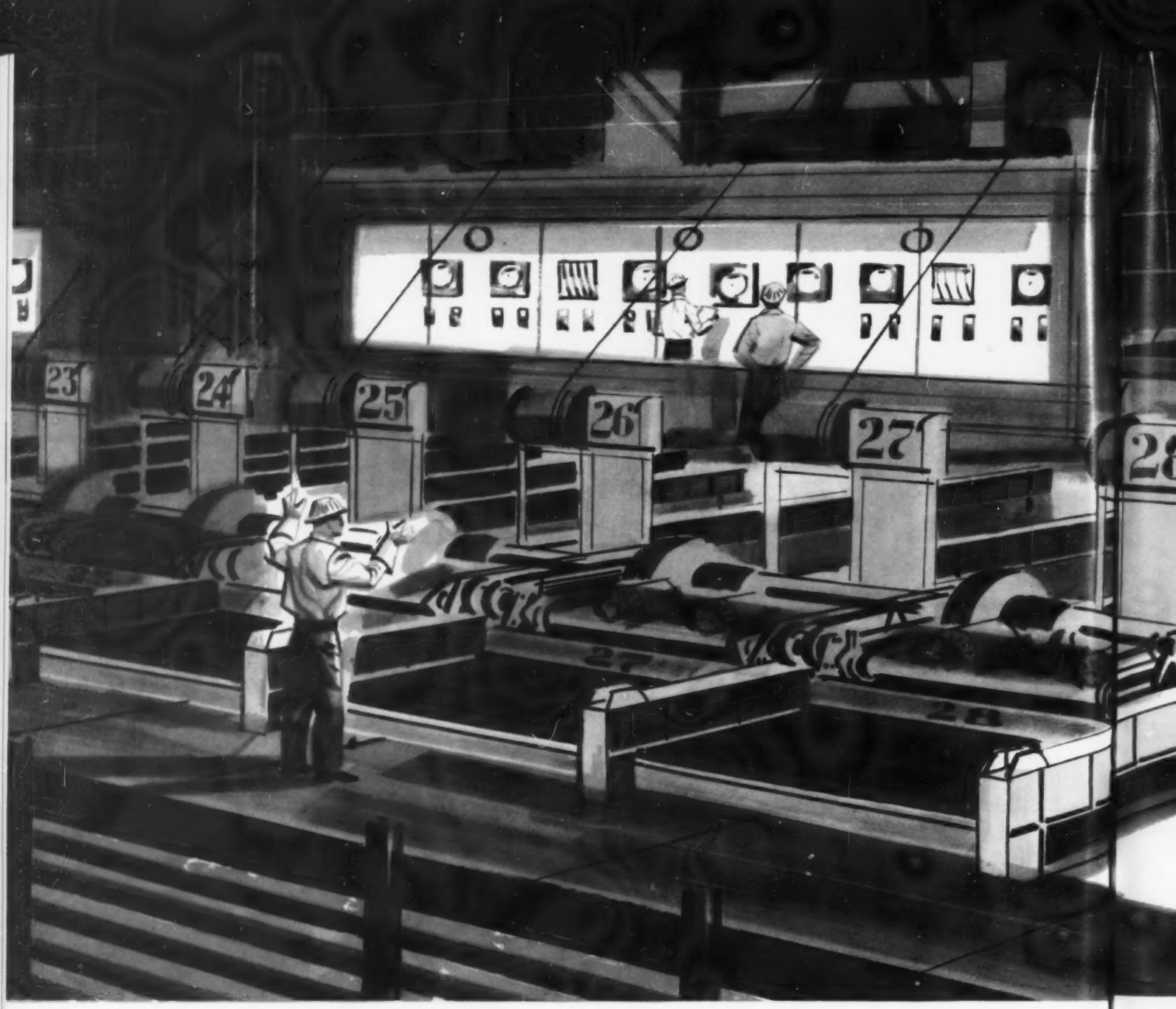
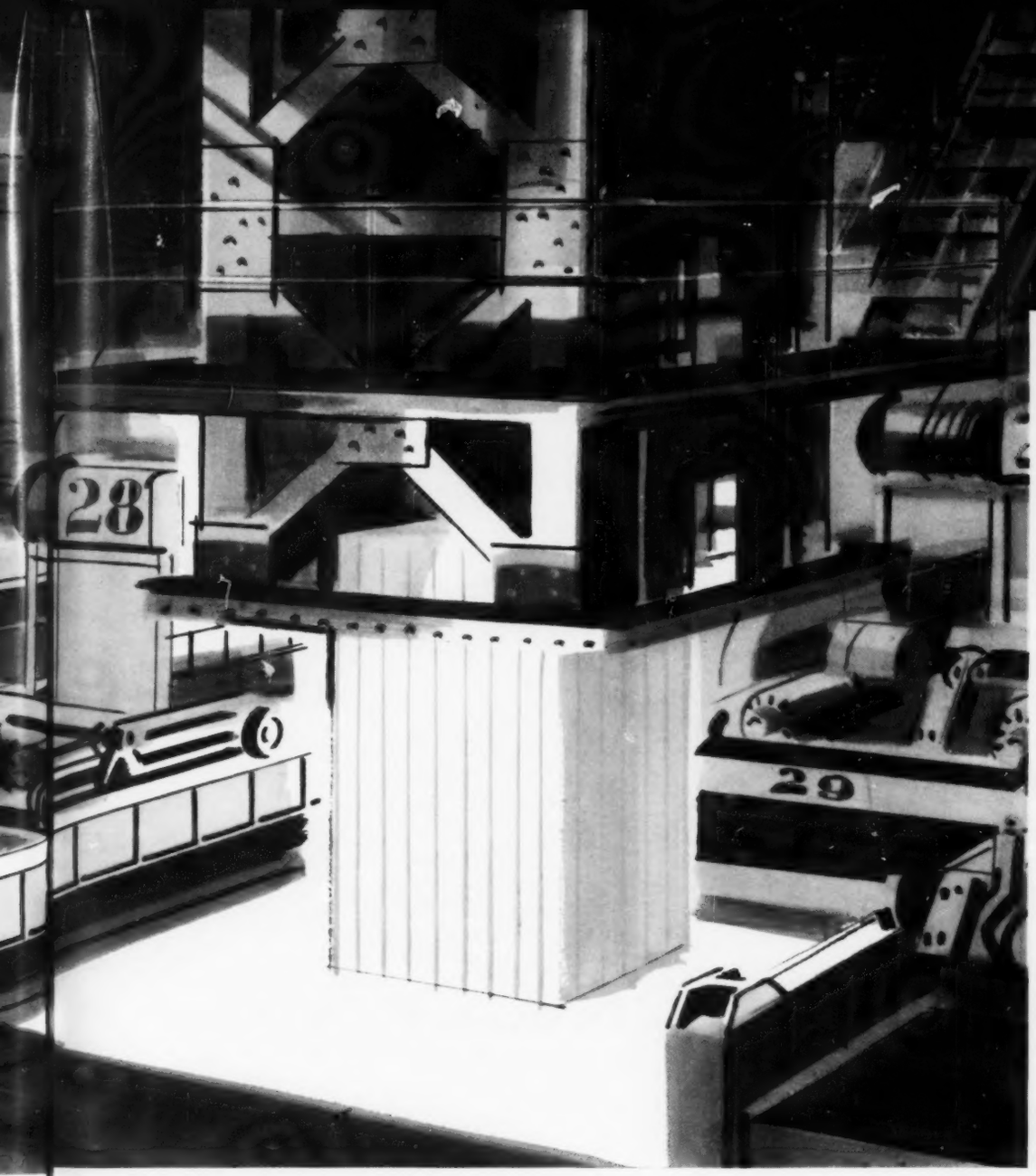


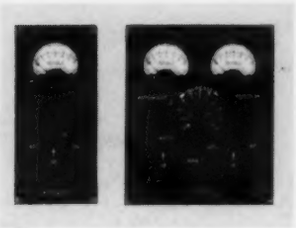
From Republic Flow Meters . . .

Complete electronic control

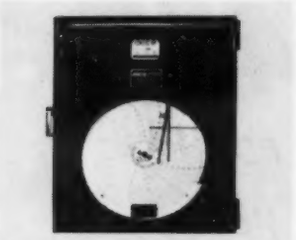
When you specify Republic Flow Meters engineering service in the designing, building and installing of electronic control systems for soaking pits, you benefit from the experience of a leading furnace control manufacturer. The complete line of Republic pneumatic and electronic equipment handles the metering, recording, indicating, and controlling of soaking pit operations for both recuperative and regenerative type furnaces. Republic controls are performing daily on soaking pit operations, handling the fuel-air ratio control, flue draft control, air and gas pressure control, air flow recording, etc.

When you install new soaking pits, or overhaul existing ones, check the important advantages you get from Republic Flow Meters Complete Control Engineering Service:

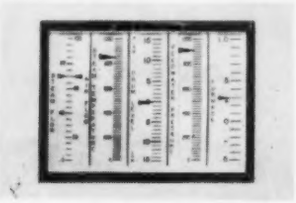




Complete electronic control systems are available for controlling the various functions in soaking pit.



Republic Flow & Pressure Recorders register electrically, pneumatically or mechanically, are simple, compact.



Republic V-5 Gauges for draft, pressure, flow temperature and differential pressures, have 5" vertical scales.

for your soaking pits

1. **Single-source service, and responsibility for controls system**
2. **Depth of engineering experience in building pneumatic and electronic control systems for over forty years**
3. **Nation-wide network of experienced field engineers, installation supervision, and final system adjustment**

For information, contact the Republic Representative nearest you, or write Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, Ill. In Canada: Republic Flow Meters Canada, Ltd., Toronto. Subsidiary of Rockwell Manufacturing Company.

Republic Final Drive Units operate valves, damper, inlet vanes, etc., in response to air loading pressures or electronic signals.

REPUBLIC INSTRUMENTS AND CONTROLS

more fine products by

ROCKWELL

435′ OF CONTINUOUS HEAT TREATING UNDER "PUSHBUTTON" CONTROL-

DREVER

ROLLER HEARTH LINE FOR TREATING BAR AND PLATE

The Drever Roller Hearth Line provides the higher output to be expected from continuous production but at the same time adds ease of operation, versatility, and uniformity of quality. Engineered as a complete coordinated unit, it hardens, quenches and tempers twelve 6" dia. x 40' long bars at a time with maximum production rate of 30,000#/hr. It can also be used to normalize carbon steel plate up to 72" wide x 40' long at a rate of 19,000#/hr.—or heat alloy steel plate to 1650°F with controlled cooling to 1300°F at a maximum rate of 9,500#/hr.

The entire operation from charge to discharge is directed from an air conditioned booth which utilizes television monitoring and radio intercommunication from booth to floor.

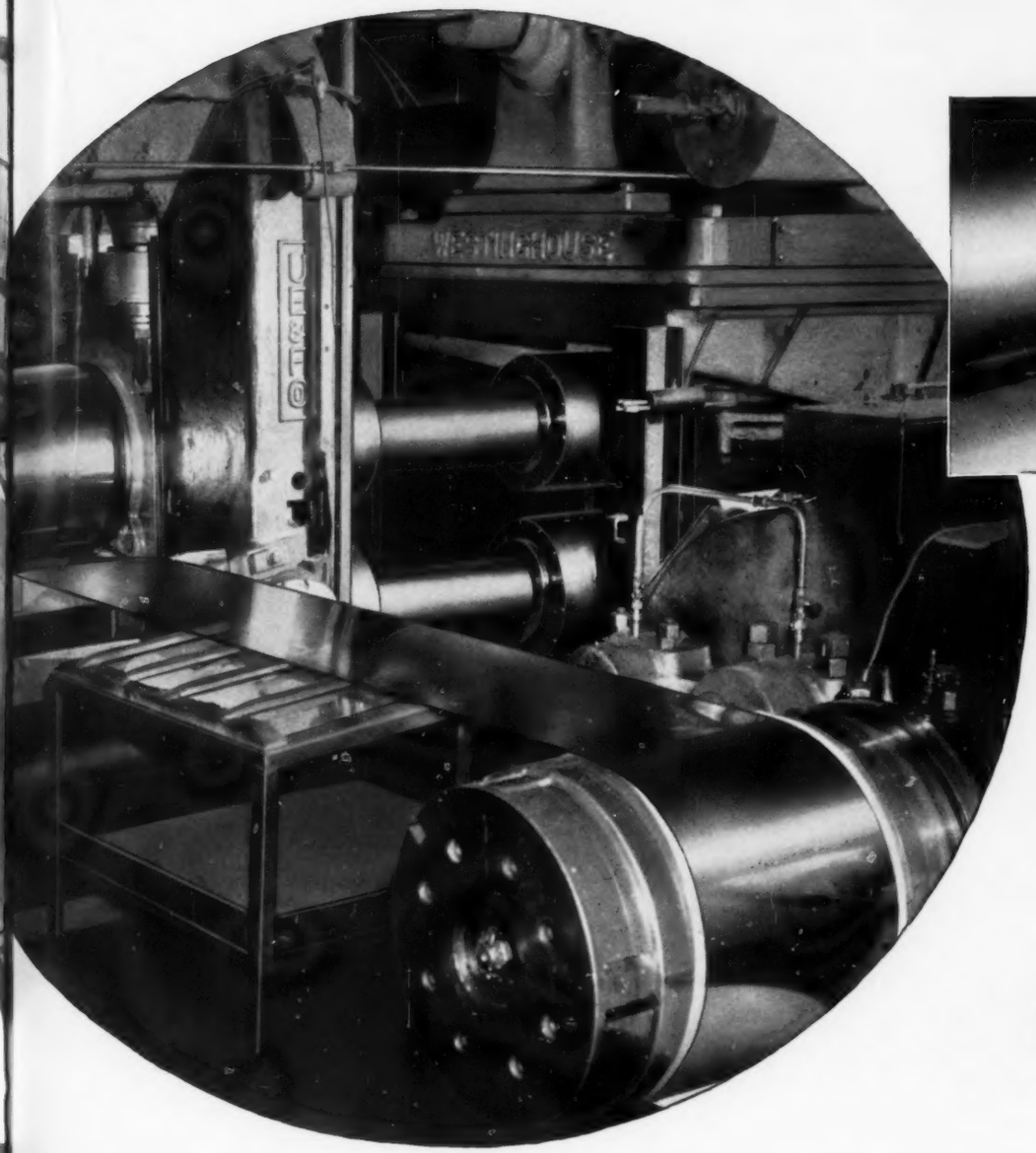
The rolls of each unit have separate drives—maximum line speed is 200 fpm, variable to a low of 0.3 fpm in the tempering furnace.

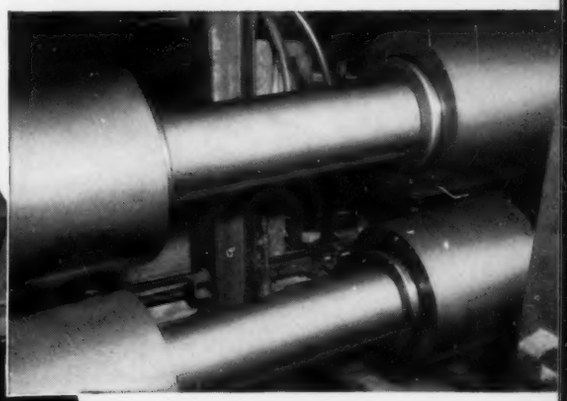
Like all Drever Heat Treating Units, the Roller Hearth Lines are engineered to be an important part of the modernization of metals production processes—and are the result of specialization since 1939. Write or phone us about your heat treating requirements.

DREVER COMPANY

BETHAYRES, PA.

Phone: Wilson 7-3400





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DIHEDRAL SPINDLE COUPLINGS

Proved by Years of Hard Service on Mills and Heavy Duty Machines Throughout Your Industry

Ajax Dihedral Spindle Couplings have been helping builders and users of new and modernized ferrous and non-ferrous mills achieve new standards of performance, quality, high production and maintenance economies.

They are operating on every type of mill and heavy duty machines including bar, rod, hot and cold strip, stretch reducing, tube straightening, temper, skin pass, shears, etc.

Ajax patented Dihedral Tooth Design, perfected lubricant seals and other features have contributed to new output records, better surface finish and closer gauge tolerance of new and modernized mills throughout the world.

Take advantage of AJAX factory trained and on-the-job field experience of Ajax Sales Representatives to give you personal liasion with the Ajax Engineering Department.

Ask for Latest Ajax SELECTION GUIDE

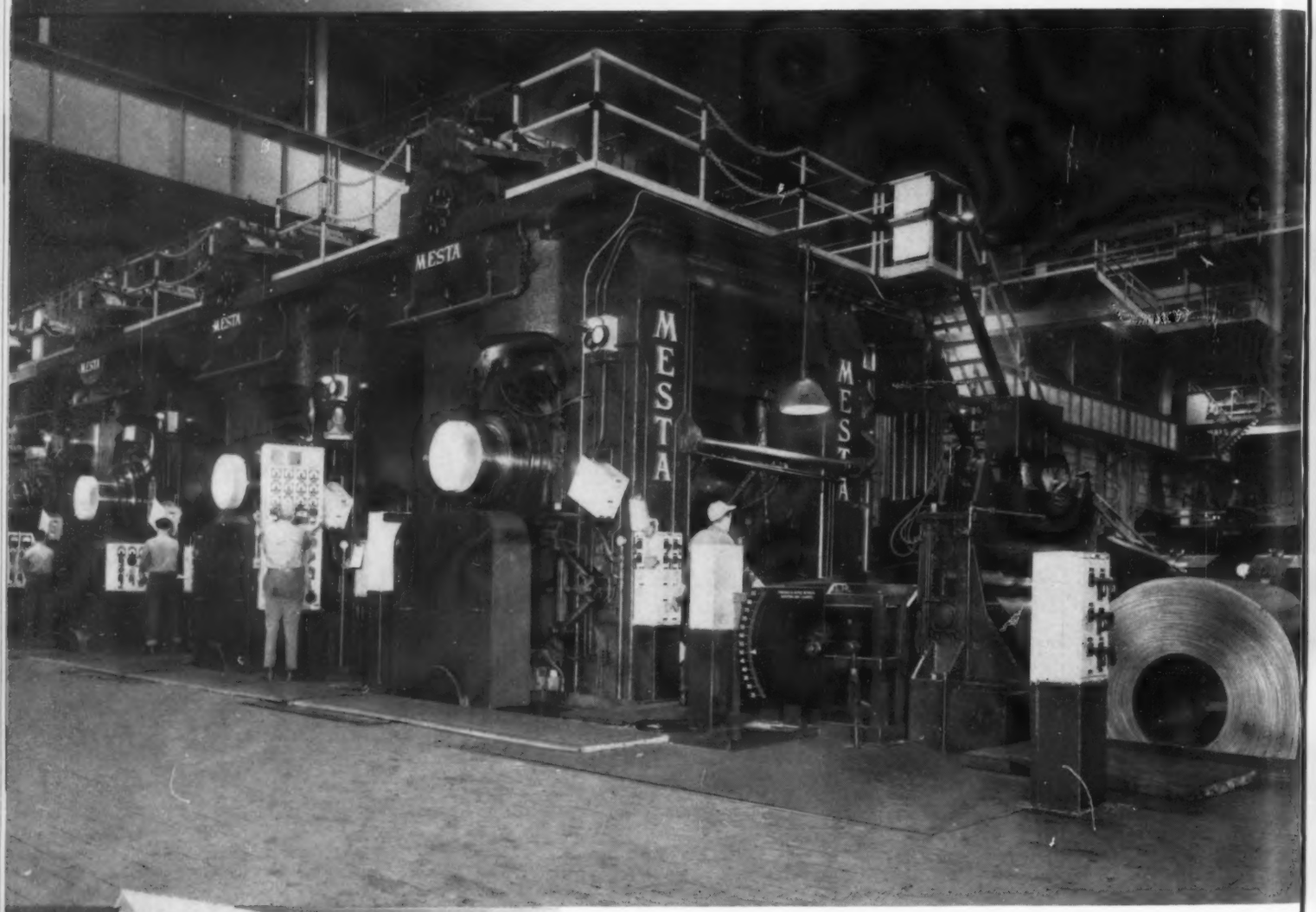
Just off the Presses

AJAX FLEXIBLE COUPLING CO. INC.

20 PORTAGE ROAD • Incorporated 1920 • WESTFIELD, N. Y.

In Canada—The Alexander Fleck Ltd., Ottawa, Ont.

HIGH SPEED COLD MILLS



Designed and Built by MESTA

MESTA 80"
Four-High, Four-Stand
Tandem Cold Mill
for Rolling Wide Strip.

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Personnel News...

Austin J. Paddock was named administrative vice president—fabrication and manufacture, United States Steel Corp., to become effective January 1, 1961. In his new responsibility, he will be in charge of the American Bridge Division, Consolidated Western Steel Division, Universal Atlas Cement Division and United States Steel Homes Division. Mr. Paddock began working with American Bridge in 1929 as a timekeeper in the Construction Department. One year later, he was transferred to the Drafting Department. Two years later he became plant rate clerk and industrial engineer. In 1934, he was appointed assistant to manager of the company's Elmira plant and in 1937, advanced to plant manager. In 1941, he was transferred to the Gary Plant where he was manager for five years. Mr. Paddock was vice president—manufacturing operations from 1946 until his appointment as vice president—contracting in 1954. He became president of American Bridge in 1956.

Loring S. Brock has been appointed president of United States Steel Products Division, U. S. Steel Corp. He succeeds **John Hauerwaas** who has retired. Mr. Brock began his career with U. S. Steel in the shipping office of United States Steel Products at Los Angeles, Calif. After advancing through various assignments with the Products Division, he was appointed a salesman for the former Columbia Steel Co. in Los Angeles in 1930, rising to manager of manufacturing accounts solicitation by 1950. In 1951, he was named inter-mountain sales manager for Columbia-Geneva Steel and district vice president, inter-mountain sales in 1952. In 1955, Mr. Brock was appointed director of the corporation's products development division in Pittsburgh, and was made manager of structural and plate products in 1957. In 1960, he was appointed executive vice president of United States Steel Products Division, the position he held prior to his present appointment.

Frank A. Baker, Jr., an assistant general manager of the Sparrows Point, Md., plant of Bethlehem Steel Co. for the past four years, was named chief engineer, Steel Division with headquarters in Bethlehem, Pa. His association with the Sparrows Point plant began in 1939 when he was employed as a repair helper in the plate mill. He also worked in the steam, bricklaying and engineering departments until 1942, when he was named field foreman in the General Mechanical Department. He was appointed an engineer in the General Mechanical Department in 1946. In 1947, he was named assistant to the chief engineer in the Engineering Department; assistant chief engineer in 1950; and chief engineer two years later. In 1956, Mr. Baker was promoted to assistant to general manager of the Sparrows Point plant and then to assistant general manager ten months later.

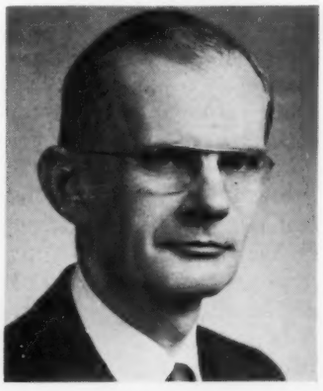
S. William Stouffer has been appointed director of construction and maintenance for Jones & Laughlin Steel Corp. Mr. Stouffer, who was J&L's assistant director of construction and maintenance, succeeds **S. C. Read**, who retired October 31 after 36 years of service with J&L, the last 12 in his present position. Mr. Stouffer started with J&L in 1931 as a student engineer at the Aliquippa Works. He became a millwright foreman at the Works' 14-in. bar mill in 1934, and was named foreman of the Tin Plate Department in 1937. After service with National Tube Co. in Pittsburgh from 1941 to 1946, he was appointed maintenance engineer at J&L's Pittsburgh Works, and became superintendent of the Eliza Utility and Mechanical Department at Pittsburgh in 1947. He was named resident construction engineer at J&L's Aliquippa Works in 1949, and became manager of construction for the corporation in 1950. He was promoted to assistant director of construction and maintenance in 1955. Mr. Read who is currently president of the Association of Iron and Steel Engineers, started with J&L in 1924 as assistant superintendent of the Power Department at the Pittsburgh Works. Before that, he had served for 12 years with the Pennsylvania Railroad. He was named master mechanic of Rolling Mills at J&L's Pittsburgh Works in 1938, and superintendent of the Blooming Department and Rolling Mills in 1946. He became J&L's director of construction and maintenance in 1948.

A. J. PADDOCK

L. S. BROCK

F. A. BAKER, JR.

S. W. STOUFFER



R. L. VAUGHN

J. D. SAUSSAMAN

R. C. MAC DONALD

M. P. ORR

Ralph L. Vaughn has been named assistant general superintendent, Technical Services, at Kaiser Steel Corp.'s Fontana, Calif., plant. He will be responsible for plant production planning, plant engineering, industrial engineering, metallurgical engineering and metallurgical and quality control. Mr. Vaughn joined Kaiser Steel in 1948 as an industrial engineer and advanced to division industrial engineer in 1950. A year later he was appointed assistant chief industrial engineer and in 1955 was named plant incentive engineer. He was appointed superintendent of the Industrial Engineering Department in 1956, the position he held until his present appointment.

John D. Saussaman has been appointed assistant general superintendent, Primary, at Kaiser Steel Corp.'s Fontana, Calif., plant. Formerly assistant general superintendent, Iron & Steel Division, Mr. Saussaman retains responsibility for the coke plant, blast furnace, basic oxygen steel, open hearth, foundry, and masonry, and in his new position has charge of the soaking pits, blooming mill, slabbing mill, structural mill, and conditioning yards. He came to Kaiser Steel in 1946 as assistant superintendent of the Blast Furnace Department. He was named superintendent two years later and in 1957 was appointed division superintendent, Iron & Steel. He was named assistant general superintendent of the Iron & Steel Division in 1958. **Reynold C. MacDonald** was named assistant general superintendent of Finishing Mills at Fontana. Mr. MacDonald will be responsible for all steel finishing departments which include the plate mill, hot strip mill, tinplate mill, continuous weld pipe mill, electric weld pipe mill, merchant-skelp, cold roll mill, specialty manufacturing and roll shop. He joined Kaiser Steel in 1946 in the Industrial Engineering Department. Transferring to the rolling mills, he became foreman and general foreman in the conditioning yards and then assistant superintendent of merchant-skelp. In 1953, he was appointed superintendent, blooming mill area; in 1956, division superintendent, rolling mills; and in 1958, assistant general superintendent, primary and pipe mills.

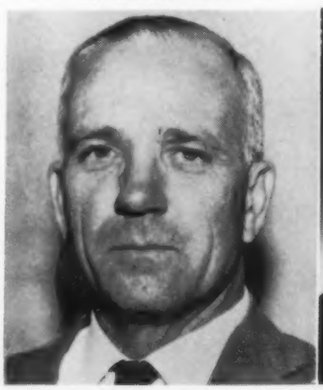
Marquis P. Orr has been appointed general sales manager of the Mackintosh-Hemphill Division of E. W. Bliss Co. In his new capacity, Mr. Orr will be responsible for sales of cast rolling mill rolls, roll turning lathes, rotary tube straightening machines, cinder pots and castings which are produced at the division's two plants at Midland and Pittsburgh, Pa. Formerly manager of roll sales, Mr. Orr started with the firm in 1941, working in various sales positions.

M. W. Reed, executive vice president, international and raw materials, United States Steel Corp. will retire December 31. He began as a wire tester at the North Works of American Steel and Wire Co. in Worcester, Mass., in 1916. He advanced through various positions in Worcester and at the New Haven, Conn., plant of the same company, to the position of superintendent of New Haven Works, which he held from 1925 to 1928. Subsequently he was promoted to the positions of assistant district manager at Worcester and chief engineer of the company at Cleveland, and in 1937 to vice president of American Steel and Wire Co. In 1939 he was appointed chief engineer of Carnegie-Illinois Steel Corp. and in 1940 became vice president—engineering. Mr. Reed became vice president—engineering of U. S. Steel Corp. of Delaware in 1949. Upon the formation of U. S. Steel Co. in 1951, he was elected executive vice president, engineering and raw materials. He was elected to his present position in 1958.

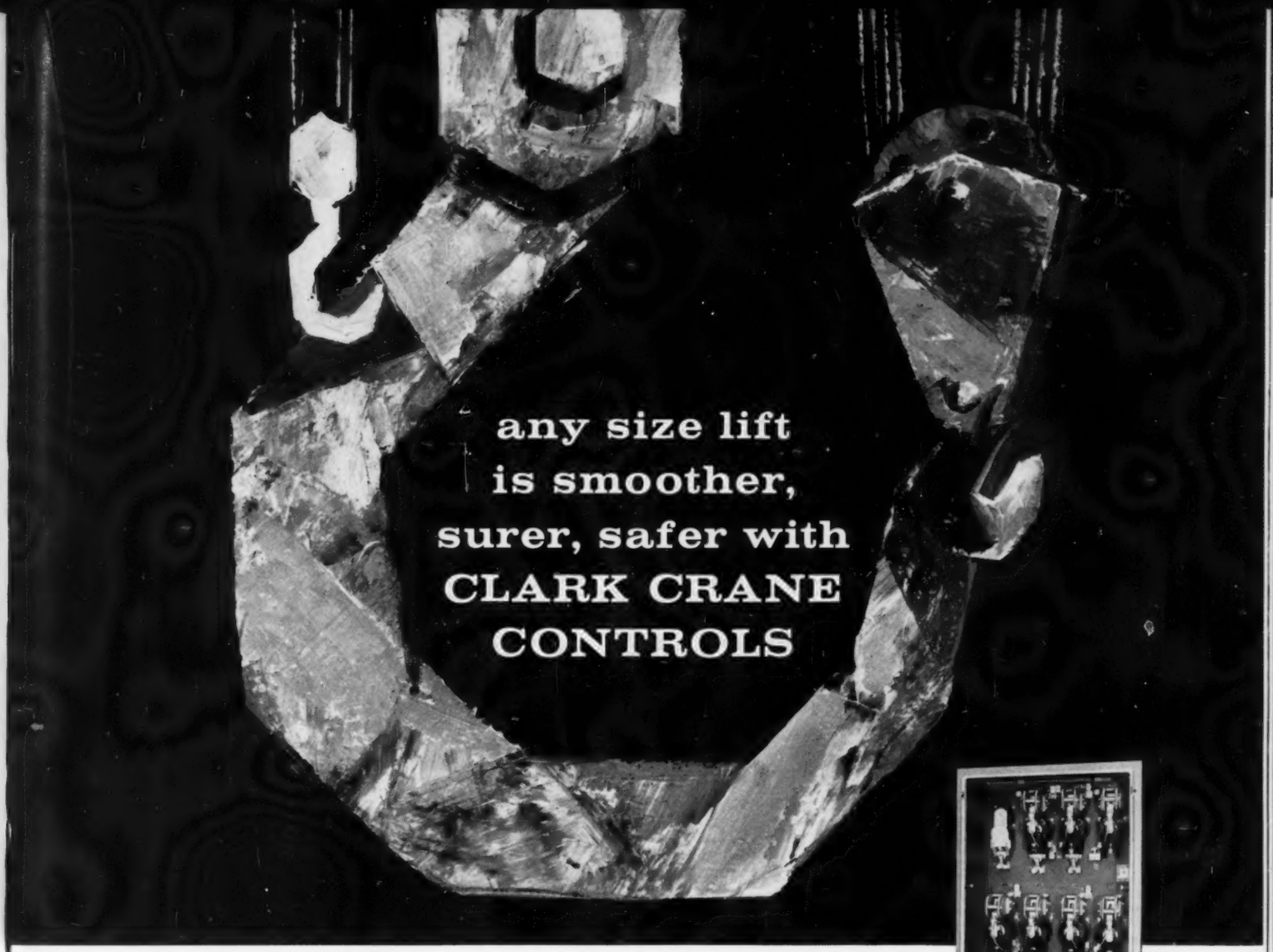
Joseph H. Proctor has been appointed manager of the Market Development Division of Lukens Steel Co. He was formerly manager of application engineering for nearly 12 years. **John D. Heffernan** has been promoted from market service engineer to manager of the Application Engineering Department.

Kenneth E. Lewis has been appointed to the newly-created position of plant manager—Detroit, Jones & Laughlin Steel Corp.'s Stainless and Strip Division.

K. E. LEWIS



A. C. PRUDNER



Whether you want a utility crane for light industrial lifting or a "big boy" for handling steel mill ladles, you'll get the best in controls by specifying Clark. All crane manufacturers are able to supply Clark Controls on any size or model crane in their line.

Complete electrical panels built by Clark have these maintenance-saving components and features:

Cushion mounting of individual components provides utmost protection of apparatus against mechanical shock and vibration.

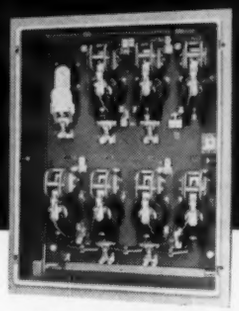
Exclusive Clark "Vari-Time" acceleration provides "guaranteed-for-life", adjustable, definite time control—combines simplicity and reliability with minimum maintenance.

Simple, two-coil Plugging Relay provides accurate reversals of crane motors, maintaining safe armature current and torque limits for maximum motor protection.

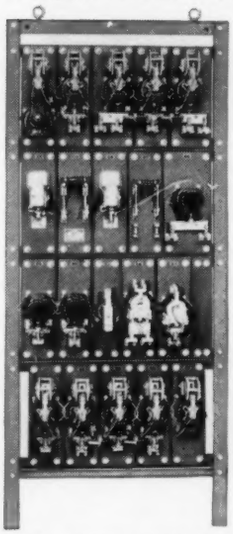
Rugged Overload Relays designed specially for heavy-duty industrial service are positive acting and easy to adjust and maintain.

Also available is a full line of crane control accessory devices including brakes, master switches, resistors and protective panels.

Your next crane can be factory-equipped throughout with reliable Clark Controls for safety and ease of maintenance. Contact your Clark sales office for a copy of the 20-page Bulletin 9100 describing "Clark D-C Crane Control". Or write to: 60C1



Travel control panel for light industrial crane.



Hoist control panel for heavy industrial crane.

The
CLARK CONTROLLER
Company

Main Plant: *Cleveland 10* • **Western Plant:** *Los Angeles 58*
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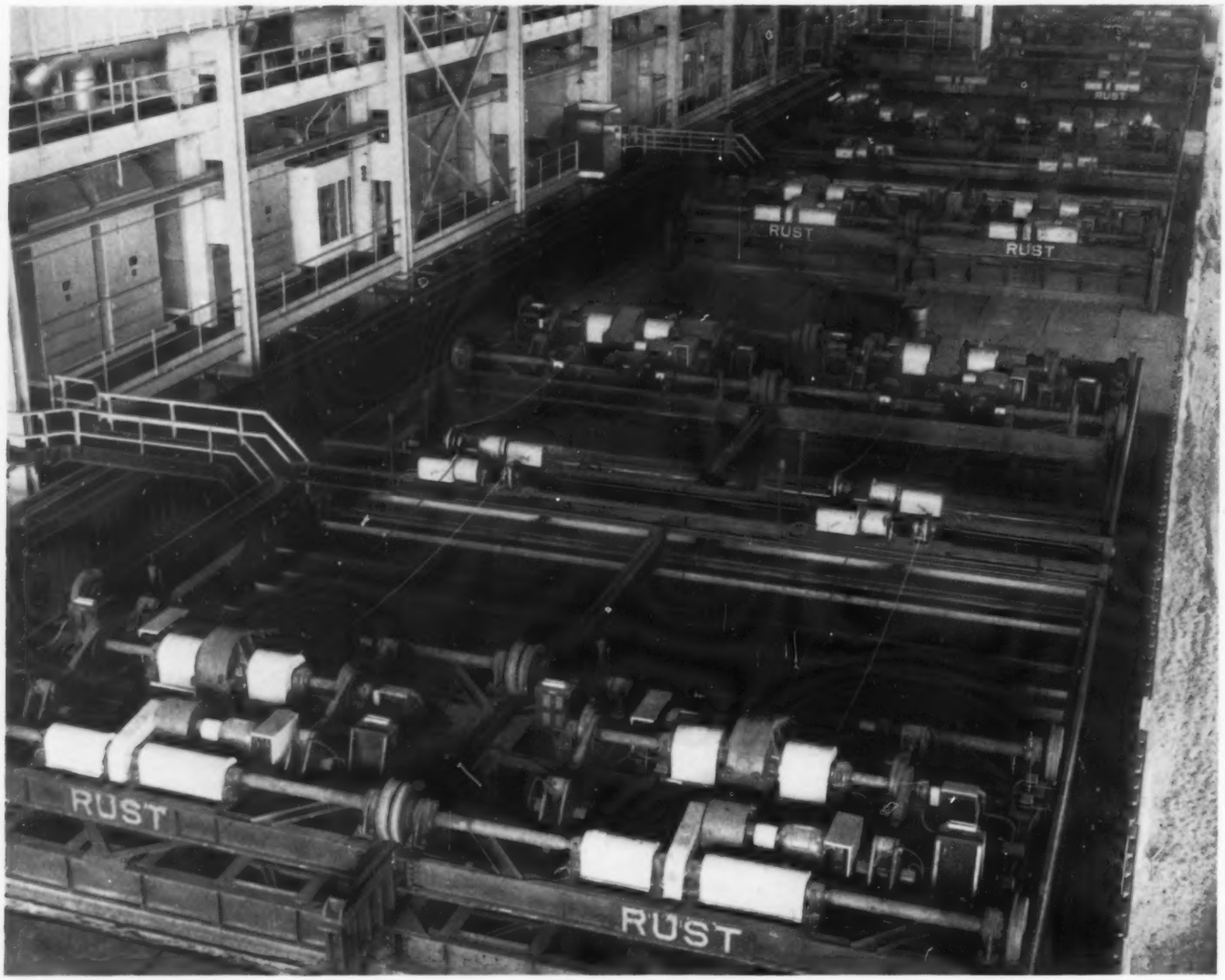
Morgan-Isley Systems WITH

SECONDARY CHECKERS IN BASES OF EJECTORS



. . . Enable large Eastern Steel Plant to use 106 Btu per cubic foot mixed blast furnace and coke oven gas in sixteen holes of cross-fired regenerative soaking pits. Checker system preheats combustion air to 2000°F. or higher.

Simple, completely modern temperature and combustion controls with automatic reversal insure rapid, efficient heating with excellent uniformity from top to bottom of ingots.

This plant also has twenty-four other holes of soaking pits equipped with the Morgan-Isley System using 117 Btu per cu. ft. gas.

Morgan-Isley Systems are in use on soaking pits using the complete range of fuels from straight blast furnace gas up to and including natural gas and oil.

Modernize your soaking pits with Morgan-Isley — consult us about your requirements.

MORGAN WORCESTER

MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS
ROLLING MILLS • MORGOIL BEARINGS • WIRE MILLS
GAS PRODUCERS • EJECTORS • REGENERATIVE FURNACE CONTROL

CCC 58

He formerly was division manager—quality and process control. **A. C. Prudner** has been named plant manager—Youngstown and will continue his former duties as manager of the Indianapolis plant.

F. G. Cartlidge has been appointed traffic manager of The Colorado Fuel and Iron Corp.'s newly created Eastern General Traffic Department. Mr. Cartlidge started his service with CF&I in 1915.

Roderick S. O'Connor has been appointed division manager of quality and process control at the Detroit, Mich., plant of Jones & Laughlin Steel Corp.'s Stainless and Strip Division. Mr. O'Connor, who joined J&L in 1959, formerly was a service metallurgist at the Detroit plant.

John L. Hallett and **Louis H. Oppenheim** have been named vice presidents of Kaiser Industries Corp. and **Franklin T. Matthias** has been named vice president of Henry J. Kaiser Co. Mr. Hallett is general manager of Kaiser Engineers International, a division of the Henry J. Kaiser Co. of which he also is a vice president. Mr. Oppenheim is general manager of Kaiser Engineers and a vice president of Henry J. Kaiser Co. He has been with the Kaiser organization since 1938, starting as a sand and gravel plant engineer. Later he was assistant chief engineer for the construction of Kaiser's Fontana, Calif., steel plant, and subsequently assistant general manager of Kaiser Engineers. He was named general manager in 1958. Mr. Matthias is manager of heavy construction for Kaiser Engineers. Before joining the organization earlier this year, he was chief engineer and director of engineering and construction, Aluminum Co. of Canada, Ltd.

Walter E. Littmann has been promoted to chief research metallurgist succeeding **Arthur L. Christenson**, who is now assistant to the general manager, Steel and Tube Operations of The Timken Roller Bearing Co. **Chester F. Jatczak** has been promoted to section chief, Physical Metallurgical Research, the position vacated by Mr. Littmann. Mr. Littmann joined Timken in 1953 as a research metallurgical engineer. He was promoted to section chief in 1958. Mr. Jatczak has been a research metallurgist with Timken since 1948.

John E. Eckert has been appointed vice president in charge of engineering by The Waterbury Farrel Foundry & Machine Co., Division of Textron Inc. Mr. Eckert served with American Rolling Mill Co. from 1937 to 1942, and with the Armzen Co. in connection with the engineering of Sendzimir mills during the period 1942 to 1956, in which year the staff of Armzen Co. was merged with Waterbury Farrel. At that time, Mr. Eckert became the chief engineer of the consolidated Rolling Mill Division. At the same time **Andrew J. Beck** was appointed chief engineer of the Rolling Mill Division of Waterbury Farrel. Mr. Beck was employed by Armzen as an engineer and advanced to the position of assistant to the chief engineer of that company prior to Armzen's merger with Waterbury Farrel. In his new position, Mr. Beck becomes the chief engineer of the consolidated Rolling Mill Division, succeeding Mr. Eckert.

Charles E. Cronauer, Jr., has been appointed assistant general traffic manager of American Steel & Wire Division, U. S. Steel Corp. Mr. Cronauer joined the Ohio Works of Carnegie-Illinois Steel Corp., at Youngstown, Ohio, in 1951 as a junior industrial engineer. In 1953, he was advanced to industrial engineer, and later that year was promoted to transportation engineer in the Pittsburgh Headquarters office. In 1954, Mr. Cronauer was named manager of transportation for American Steel & Wire in Cleveland. Four years later, he became assistant to the general traffic manager of the Wire Division.

Charles W. Elston has been named general manager of General Electric Co.'s Large Steam Turbine-Generator Department at Schenectady, N. Y. Formerly general manager of the Gas Turbine Department, Mr. Elston succeeds **W. E. Saupe** who will retire December 31. **Alan Howard,** who has been manager-engineering for the Medium Steam Turbine, Generator and Gear Department at Lynn, Mass., will succeed Mr. Elston as general manager of the Gas Turbine Department.

Edward C. Gumpf has been promoted to superintendent of transportation and materials handling and **Dale E. Sherrett** has been promoted to general foreman of materials handling for The Timken Roller Bearing Co.'s Steel and Tube Division in Canton, Ohio. Mr. Gumpf joined Timken in 1947 as a supervisory trainee in the Materials Handling Department. He became a foreman in the department in 1948, general foreman in 1950 and was named superintendent of materials handling in 1959. Mr. Sherrett joined Timken in 1946. He became foreman in the Labor Department in 1950

W. E. LITTMANN

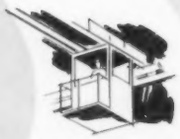
C. F. JATCZAK

J. E. ECKERT

A. J. BECK

Warmth for isolated workers

IN PULPITS...



CRANE CABS...

ORE BRIDGES... ELSEWHERE

THE
LINTERN
Circulates... Ventilates **HEATER**

The Lintern Heater takes less space and yet provides more effective heat distribution than any heater previously offered for crane cabs, watchmen's shanties and similar confined areas. An optional filter is available where dirt is a problem. Installs on ceiling, wall or floor. Low in cost, compact in size, light in weight, highly dependable. Available in all AC or DC voltages.

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Larco, inc.

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J. E. SPEARMAN

M. A. NYE

and was named foreman in the Materials Handling Department in 1955, the position he held prior to his present promotion.

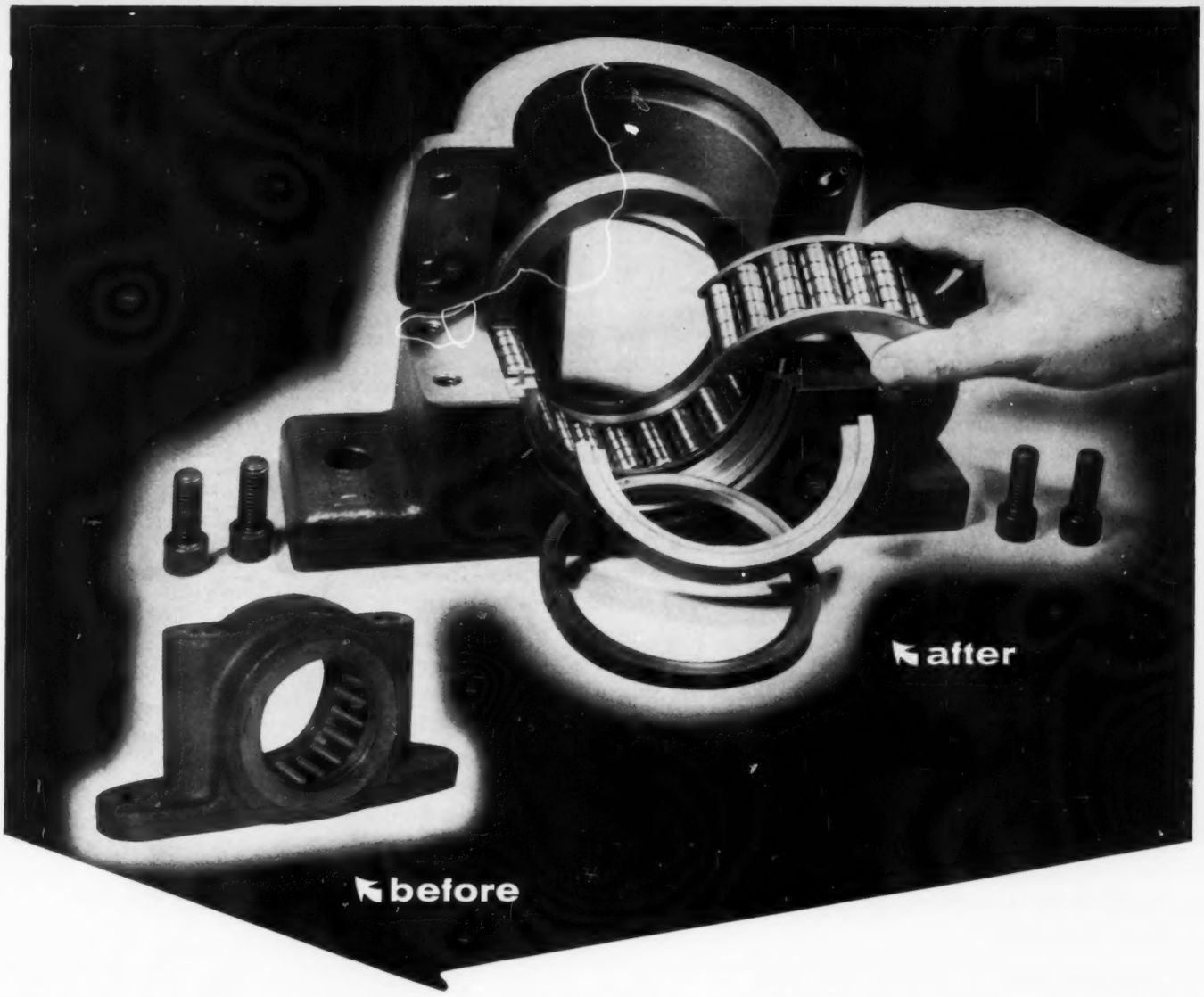
James E. Spearman was named vice president—sales and **Maurice A. Nye**, vice president—engineering by The Vaughn Machinery Co. Mr. Spearman had been sales manager and assistant to the president, and Mr. Nye had been chief engineer. Mr. Spearman has been with Vaughn for 20 years, serving in purchasing and sales departments prior to his appointment as assistant to the president in 1954. While retaining the duties of that office, he also became sales manager in 1958. Mr. Nye started with Vaughn in the Engineering Department in 1927. He became assistant chief engineer in 1950 and chief engineer in 1954.

William H. Grinold has been elected president of The Wallingford Steel Co., a subsidiary of Allegheny Ludlum Steel Corp., effective January 1, 1961. He succeeds **Edmund B. Cleborne,** who at the end of this year is retiring as president of the company he founded in 1922. He remains as a director of Allegheny Ludlum Steel Corp., chairman of Wallingford Steel, and a director of The Arnold Engineering Co., another Allegheny Ludlum subsidiary. The company's board of directors announced the election of **Guy Cleborne** as vice president, in addition to his office of treasurer.

Don T. Hanbery has been appointed manager of the new Falk Corp. district office in Minneapolis, Minn. **H. R. Harris,** former Falk representative for over 30 years, will continue in a consulting capacity. Mr. Hanbery has been associated with Falk since 1957. After completing a sales orientation course, he was assigned to the Detroit office as a sales engineer, a position he held until moving to Minneapolis this year.

James H. Mumper has been named chief engineer of Jessop Steel Co. and subsidiaries. He first joined Jessop's Engineering Department in 1942 and became plant engineer in 1957, the position he held prior to his promotion. He began his career in the steel industry in 1935 at Wheeling Steel Corp., and joined Jessop seven years later. He left Jessop in 1945 to take an engineering post at Frazier-Simplex Inc., and returned in 1951 as assistant plant engineer.

Elmer G. Peterson, Cutler-Hammer staff sales consultant, has retired after 43 years with the firm. Mr. Peterson joined Cutler-Hammer in 1917, working



Here's a "before" and "after" bearing problem solved by Bearings, Inc.

A large steel mill customer has six cranes with bridge line shafts equipped with the solid housing pillow blocks shown in the "before" photograph. Whenever one of the line shaft bearings needed to be replaced, the entire section of shaft had to be removed. Maintenance costs and crane downtime were excessive and costly. Our engineers were asked for a solution.

THE PROBLEM: Due to the extremely low base to center of shaft dimension of the original bearing, a conventional split housing, split roller bearing pillow block could not be used.

THE ANSWER: We designed and furnished a special split housing pillow block (see "after" photo) incorporating split bearings and split seals which maintain the original dimensions. These can be installed or replaced on the crane in a fraction of the time formerly required just to dismantle the line shaft.

This is just one of many successful solutions of a tough bearing problem. We can help you solve your bearing problems and supply replacement bearings from the stock carrying branch near you. We're authorized distributors for all nationally known bearings. Call us!

Providing bearing service

in the North → **BEARINGS, INC.**

DELAWARE: Wilmington • **ILLINOIS:** Neiman Bearings Co., E. St. Louis • **INDIANA:** Ft. Wayne • Indianapolis • Muncie Terre Haute • **MARYLAND:** Baltimore • **MISSOURI:** Neiman Bearings Co., St. Louis • **NEW JERSEY:** Camden • Newark **NEW YORK:** Balanrol Corp., Buffalo • Niagara Falls • **OHIO:** Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton Lima • Lockland • Mansfield • Painesville • Toledo • Youngstown • Zanesville • **PENNSYLVANIA:** Erie • Johnstown • Philadelphia • Pittsburgh • York **WEST VIRGINIA:** Charleston • Huntington • Parkersburg • Wheeling

and

in the South → **DIXIE BEARINGS, INC.**

ARKANSAS: Little Rock • **FLORIDA:** Jacksonville • **GEORGIA:** Atlanta • **KENTUCKY:** Louisville • **LOUISIANA:** Baton Rouge New Orleans • **N. CAROLINA:** Charlotte • Greensboro • **S. CAROLINA:** Greenville • **TENNESSEE:** Chattanooga • Kingsport • Knoxville Memphis • Nashville • **VIRGINIA:** Norfolk • Richmond • Roanoke

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SCHLOEMANN
ROLLING MILLS · HAMMERS · PRESSES

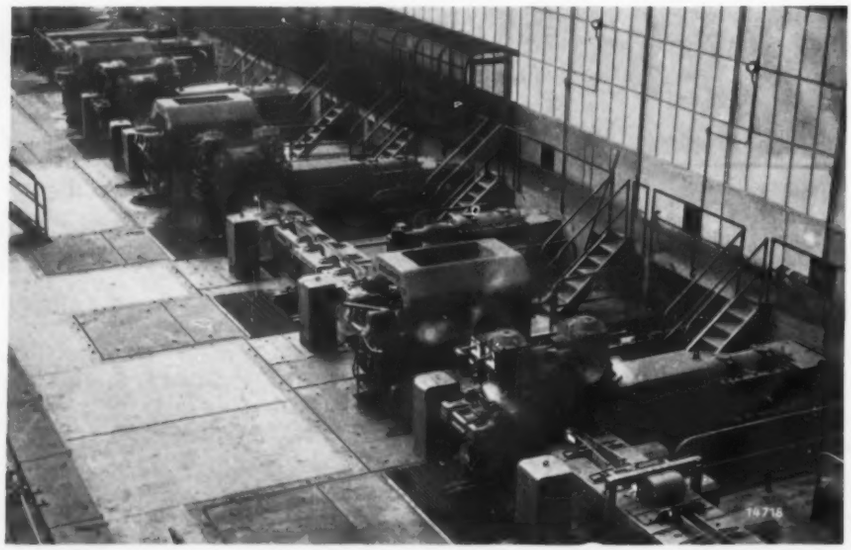
Advanced Design Bar and Rod Mill Proved Success

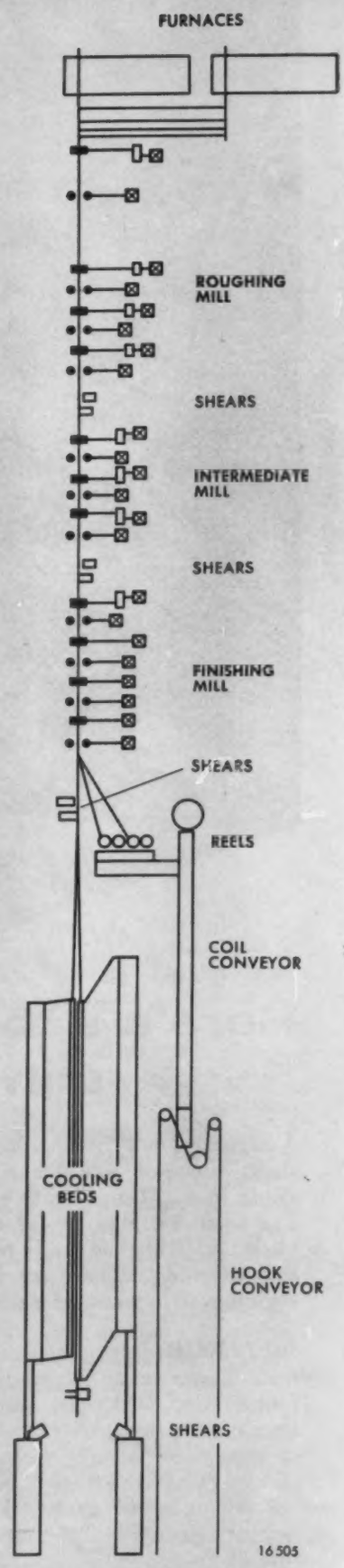
In 1951, Fiat of Italy placed a contract with SCHLOEMANN for the construction of a bar and rod mill. Designed primarily for rolling high grade and alloy steels to very close tolerances, mass-produced qualities were also to be handled. SCHLOEMANN solved this problem in a manner that was revolutionary at the time: The complete continuous mill is laid out with individually driven horizontal and vertical stands. This eliminates a 90° twist in between each stand, and besides improving the quality, closer limits may be held on the finished material. They are ± .004 in. for single-strand and ± .008 in. for double-strand rolling of .025 in. rounds.

Interchangeable stands complete with accessories are provided for the intermediate and finishing trains. The horizontal or vertical traverse of the stands to the roll face, as the case may be, is powered hydraulically. Stands not needed when rolling large sections may be hydraulically removed from the rolling path. Automatic speed control of the mill motors in the intermediate and finishing trains is obtained through loop lifters. In 1957 the mill's capacity was extended through the addition of a second cooling bed. This plant provides proof that SCHLOEMANN combines progressive engineering with utmost operational economy.

Technical data

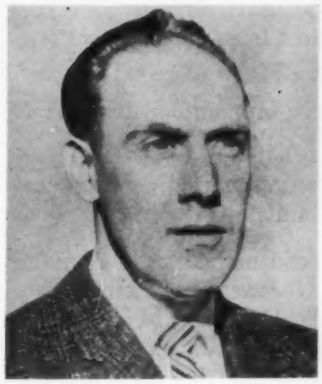
Starting material	
Cross section	$2^3/_8$, $3^1/_2$ and $4^3/_4$ in. sq.
Length	13 ft.
Weight	240, 550 and 980 lbs.
Finished products	$^{13}/_{64}$ to 2 in. rounds and corresponding sections
Type of rolling	single and double-strand
Output	60 tons an hour





SCHLOEMANN-built bar and rod mill in H/V layout at the Fiat works.

FELLER ENGINEERING COMPANY Empire Building, Pittsburgh 22, Pa.



J. W. RUSSELL (left)
J. W. WALLACE (center)
F. H. NORTON (right)

in the Engineering Department. He later served in the Pittsburgh sales office and was appointed a divisional sales manager in 1936, a post he held until appointed to his most recent position in 1958.

John W. Russell has been promoted to the position of assistant works manager at the National Roll & Foundry Division of General Steel Castings Corp. at Avonmore, Pa. Mr. Russell has been associated with the firm since 1957 and has held the positions successively of iron foundry superintendent and superintendent in charge of both the iron and steel foundries. Prior to joining National Roll, he was research metallurgist for Continental Foundry & Machine Co. Previously he was roll foundry foreman at Mesta Machine Co.

J. Walter Wallace has been appointed general sales manager for National Bearing Division, American Brake Shoe Co. Mr. Wallace, formerly regional sales manager, will be located at the Division's major plant in Meadville, Pa.

Frederick H. Norton was named as regional sales manager of the east central sales region of the Baldwin-Lima-Hamilton Corp. He will service Ohio, West Virginia, western Pennsylvania and eastern New York. Mr. Norton comes to B-L-H from Pittsburgh Forgings Co. where he was vice president for sales. Previously he had been vice president for sales of the American Car and Foundry Division, A.C.F. Industries.

E. J. Skeehan has been appointed assistant vice president of Sommerfeld Machine Co., Inc. Mr. Skeehan was formerly associated with Sawhill Tubular Products Inc. as general plant engineer for all company plants. Prior to this he had served in various engineering capacities with United States Steel Corp., United Engineering and Foundry Co., and Blaw-Knox Co.

EXECUTIVE REPORT #11

HERE CARBON STEEL SHEDS ITS SCALE

Wheelabrator® Descaling Enables 100% Increase in Production

Every ton of steel produced in the modern mill of Altos-Hornos De Mexico, S.A., at Monclova, Coahila, is run through a Wheelabrator airless blast descaling cabinet. In a typical month, over 15,500 tons of carbon steel from a hot Steckle reversing type mill was Wheelabrator descaled followed by a light pickle rinse. The end product is reduced on reversing cold mills for sale as cold rolled steel, tin plate, and galvanized stock.

Steel is descaled in this new line at a rate of up to 200 f.p.m. contrasted to a speed of only 100 f.p.m. when acid pickling was used exclusively for descaling. Even with this increase in production, acid consumption has been cut in half and overall descaling costs materially reduced.

Wheelabrator Engineering Experience At Your Service

Write today for information on how Wheelabrator descaling can cut your costs and speed production. Wheelabrator Corporation, 396 S. Byrkit St., Mishawaka, Indiana. In Canada, P.O. Box 490, Scarborough, Ontario.

WHEELABRATOR
AIRLESS BLAST EQUIPMENT

R. F. STEWART

J. N. HUTSON

Robert F. Stewart has been elected a vice president of Joy Manufacturing Co. and general manager of the Western Precipitation Division. He has been assistant general manager of Western Precipitation division for the past year. Since joining the company in 1946 he has been divisional vice president, sales manager, manager of proposal and contract and a sales engineer for the division.

John N. Hutson has been appointed North Central regional manager of Federal Pacific Electric Co. Previously Mr. Hutson was district sales manager in Birmingham, Ala.

T. R. Elmblad and **A. C. Kukral** have been named managers of Whiting Corp.'s New York Domestic and Cleveland sales offices, respectively. Both were formerly in the Cleveland office, Mr. Elmblad as manager.

R. J. Enroth moves from the Chicago office to New York Domestic and **F. R. Schwantes** from Chicago to Cleveland.

John R. Dunlap has been appointed manager of E. J. Lavino and Co.'s Alloy Sales Dept.

Douglas J. Taylor has been appointed ceramic engineer, field services of The Ramtite Co.

George F. Marriott has been named superintendent of the Indianapolis Plant of Jones & Laughlin Steel Corp.'s Stainless and Strip Division. Mr. Marriott formerly was superintendent of rolling and pickling at the Indianapolis Plant. He joined J&L in 1929.

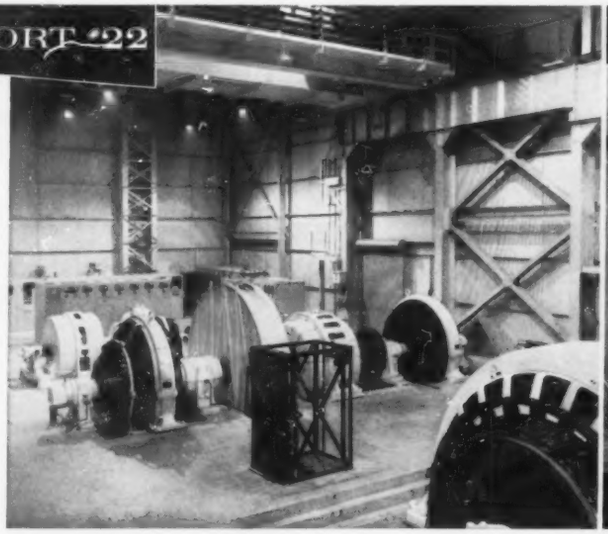
Robert I. Baierbach has been appointed to the position of chemical engineer at the Tin Plate Department, Aliquippa Works of Jones & Laughlin Steel Corp. Mr. Baierbach, who was assistant to the general maintenance foreman, Tin Plate Department, succeeds **John K. Sargent,** who has accepted a position with another company. Mr. Baierbach has been with J&L since 1953, when he started in the Maintenance Department. He entered the J&L Training Program in 1955, and, upon completion of his training, was named maintenance engineer in the Pittsburgh Works 96-in. hot strip mill. He became assistant to the general maintenance foreman in the Tin Plate Department, Aliquippa Works, in 1959.

F. Guy White, technical director of the Granite City Steel Co. and the company's spokesman on a wide variety of steel industry technical committees and engineering committees, has retired after 42 years

EXECUTIVE REPORT #22

NO ROOM FOR DUST

In Acme Steel's New Blooming Mill Motor Room



Even the air you breathe isn't pure enough to meet the demands for air to ventilate the motors and generators in Acme Steel Company's new Riverdale, Ill. plant. Wheelabrator Ultra-Filtration® provides air that is ultra-pure for the exacting requirement of their blooming mill motor and control room. Furnishing 135,000 cfm of super-filtered air, this installation has been functioning with absolutely no maintenance, and no filter change since its installation in 1959.

FILTRATION EFFICIENCES OF 99.9% ARE FREQUENTLY ACHIEVED BY WHEELABRATOR

Ultra-Filtration equipment provides filtration efficiencies of above 99%, measured both by weight and discoloration. For details of this economical air filtering equipment write to **Wheelabrator Corp., 396 S. Byrkit St., Mishawaka, Ind. In Canada, P. O. Box 490, Scarborough, Ont.**

WHEELABRATOR
DUST AND FUME CONTROL

of service. Mr. White started as a chemist in 1918 in the Steelworks Department of the National Enameling and Stamping Co., the corporate predecessor of Granite City. He organized Granite City Steel's Department of Metallurgy and Inspection in 1935, and was head of that department until 1945 when he was appointed technical director.

A. S. Blodget, Jr., has been appointed regional vice president of Air Reduction Sales Co.'s midwestern region. He joined Air Reduction in 1938. He was first assigned to the company's Stores and Order Department and subsequently to Washington, D. C., as a sales representative for government sales. Later he was appointed manager of the Worcester, Mass., store; assistant manager of the Boston district and in 1950 was made manager of the Boston district. In 1952 he was appointed Pittsburgh district manager. Previous to his current promotion Mr. Blodget was sales manager of the eastern region, a position he held since 1957.

J. Thomas Hodges has been appointed metallurgical service engineer—flat rolled products for Jones & Laughlin Steel Corp. Mr. Hodges, who formerly was assistant to the director of technical services in J&L's general office, Pittsburgh, will provide field technical service on sheet mill and tin mill products for J&L's Philadelphia, New York, Boston and Baltimore district sales offices. He succeeds the late **Regis P. Grace.** Mr. Hodges joined the J&L technical organization at the Cleveland Works in 1949. He served in various metallurgical positions in the Cleveland blast furnace, blooming mill and open hearth departments, and was transferred to J&L's general office as a contact metallurgical engineer—sheet mill products in 1955. He was named assistant to the director of technical services in 1956.

Pierce Hollingsworth has been appointed manager of the Industrial Gas Cleaning Department, Metal Products Division, Koppers Co., Inc. He had been chief engineer of the division's Coupling Department since 1956.

Benjamin H. Pritchard and **William B. Seemann** have been named assistant purchasing agents by The Youngstown Sheet and Tube Co. Mr. Pritchard joined the company's Purchasing Department in 1939, became a buyer in 1952 and a buyer group leader in 1956. Mr. Seemann has been with Youngstown since 1938, serving in various Purchasing Department positions.

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Slitting and Coiling Lines
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Power Squaring Shears • Automatic Resquaring • Corrugating
Culvert • Steel Mill Equipment

STAMCO, Inc., New Bremen, Ohio

EXECUTIVE REPORT #9

THEY BLAST BRIDGES BEFORE THEY'RE BUILT

Blast Cleaning Structural Steel Provides Big Savings

Prominent structural steel fabricating plants now blast clean all shapes and sizes of structural steel channels, angles, plates, bar and rod stock—in Wheelabrator cabinets.

The straight-line production made possible by Wheelabrator airless blast cleaning has improved manufacturing efficiency and reduced their cleaning costs substantially. And the shot-blasted finish has proven to be ideal for lasting surface protection of the finished structural members.

Wheelabrator's unequaled experience in descaling structural steel is at your service. Send for new informative bulletin No. 152-D. Write to Wheelabrator Corp., 396 S. Byrkit Street, Mishawaka, Ind. In Canada, P. O. Box 490 Scarborough, Ont.

WHEELABRATOR
AIRLESS BLAST EQUIPMENT

SWINDELL

Advanced Furnace Design

As manufacturers of electric arc melting furnaces for almost half a century (and steel mill furnaces generally for over one hundred years), Swindell-Dressler has pioneered many of the significant advances in this field. Today's Swindell electric arc units, ranging from a few hundred pounds capacity to 200 tons and more, embody every modern feature for *increased production rates—lower production costs—improved quality of product.*

Check these SWINDELL advantages: • Remote Roof Cylinder Mounting • Flush Door Mechanism • 3 Point Roof Suspension • Expendable Shell Panel Construction • Mechanical Tilting

From the "last word" in turntable top-charging 40 years ago to the Swindell giants of today . . .

ENGINEERING and MANUFACTURE for fine steel production

A Typical Swindell-Dressler Modernization Job—from open hearth to electric melt shop—in MONTHS!

Experienced Plant Engineering

Swindell-Dressler engineering for the steel industry covers the broadest range of projects . . . whether modernization of a melt shop as above, or construction of complete mills from site evaluation to owners' keys. Our services are available to the extent required by the client, and run from preliminary studies and estimates, throughout layout, design, plans and specifications to construction, equipment installation, procurement and all coordinate activity. ● Discussions? Promptly, at your convenience.

SWINDELL-DRESSLER CORPORATION

ENGINEERS • CONSTRUCTORS • MANUFACTURERS

PITTSBURGH 30, PA.

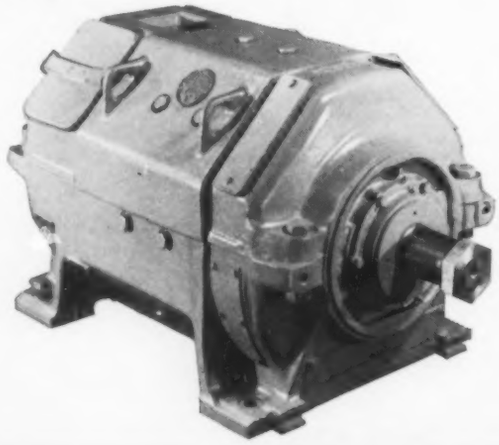
The SWINDELL-DRESSLER CORPORATION of Canada, Ltd.,
Ottawa, Canada

SUBSIDIARY OF PULLMAN INCORPORATED

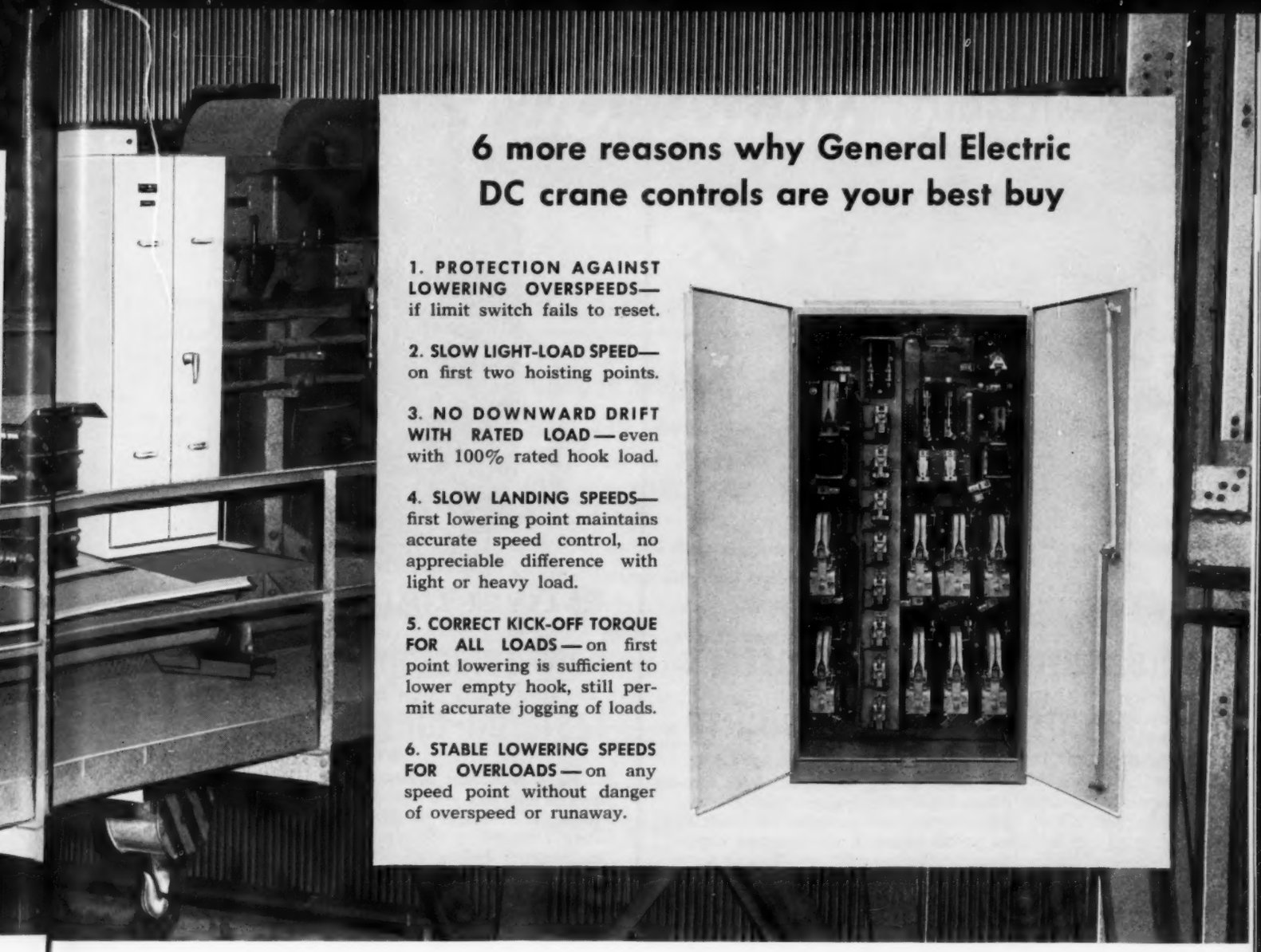
WITH G-E FRONT-CONNECTED DC CRANE CONTROL

Eliminate need for back aisles, reduce

MD-600 MOTORS . . . the sturdiest, most versatile mill motors on the market



The General Electric MD-600 totally-enclosed armored motor is built for the heavy-duty handling requirements of steel mills. When used in combination with General Electric d-c crane control, you get outstanding performance, minimized maintenance, and your crane-drive lasts longer. The MD-600 motor accelerates heavy loads quickly, handles heavier long-time overloads, and withstands frequent heavy-duty cycles. Maintenance is simplified by the split frame which swings open almost 180 degrees to allow the armature to be lifted straight out. The MD-600's heavy cast-steel frame is sturdy—it's designed to withstand the most severe shock. Since its introduction in 1947, the MD-600 motor has earned its reputation as the sturdiest, most versatile mill motor available.



6 more reasons why General Electric DC crane controls are your best buy

1. PROTECTION AGAINST LOWERING OVERSPEEDS—if limit switch fails to reset.

2. SLOW LIGHT-LOAD SPEED—on first two hoisting points.

3. NO DOWNWARD DRIFT WITH RATED LOAD—even with 100% rated hook load.

4. SLOW LANDING SPEEDS—first lowering point maintains accurate speed control, no appreciable difference with light or heavy load.

5. CORRECT KICK-OFF TORQUE FOR ALL LOADS—on first point lowering is sufficient to lower empty hook, still permit accurate jogging of loads.

6. STABLE LOWERING SPEEDS FOR OVERLOADS—on any speed point without danger of overspeed or runaway.

floor-space requirements 50 percent

General Electric front-connected d-c crane control —introduced in 1957—makes back aisles unnecessary . . . cuts floor space needs by one-half. The modern design—in a smaller cabinet—allows installation on a smaller bridge, permitting closer hook approach to the ends of your building. The control is safer, lasts longer, and needs only minimum maintenance.

General Electric d-c crane control is performing dependably on many heavy-duty jobs—ladle cranes, soaking pits, skullcrackers, and scrap and slab yards. Over 125 hoist controls utilizing this front-connected design are installed and operating reliably.

Check these important benefits of General Electric d-c crane control for the steel industry.

Less maintenance—Definite time acceleration and deceleration provide excellent commutation and motor operation of d-c cranes . . . reduce maintenance.

Greater personnel safety—All devices are serviced from the front . . . no need to work behind panel.

Fewer spare parts—D-c crane controls and mill-drive controls use same devices . . . fewer spares needed.

Longer equipment life—Heavy-duty unit bases and picture-frame construction provide long service.

For complete information on General Electric d-c crane control **and** MD-600 crane-drive motors, contact your nearest G-E Apparatus Sales Office or write Sect. 785-12, General Electric Co., Schenectady, N. Y.
Industry Control Dept., Salem, Virginia
Direct Current Motor and Generator Dept., Erie, Pa.

Progress Is Our Most Important Product

GENERAL ELECTRIC

MILL-DUTY ACCESSORIES

MASTER SWITCHES

Heavy-duty design offers long life, high reliability

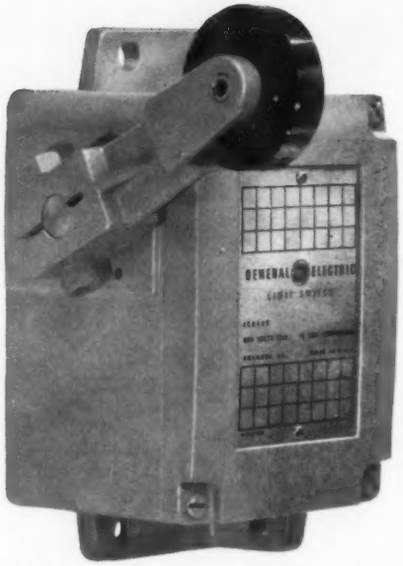
Self-lubricating phenolic cams—impregnated with graphite—keep General Electric master switches performing longer . . . even in the toughest conditions. Numerous mill installations show that these cams—coupled with steel cam followers—will operate millions of times without replacement.

Modern design of the G-E master switch permits quick modification—with a minimum of parts—to perform different sequences. And, cams can be interchanged without disassembling the switch. Offered in surface- or deck-mounted models, these switches are 25% smaller than other designs.

Check these "extra-value" features of General Electric master switches:

- **Entire switch unit** lifts out of enclosure for ease of wiring and mounting.
- **Pawl arrangement** allows for convenient adjustment to each operator's "feel."
- **Adjustable stops** give maximum of seven points in each direction, plus off.

Want more information? See your G-E Sales Engineer; or write Sect. 784-28, General Electric Co., Schenectady, N. Y. for Bulletin GEA-6706. *Industry Control Dept., Salem, Va.*



LEVER LIMIT SWITCHES

New adjustable cams permit fast, on-the-job adaptation

Here is a new lever-operated limit switch that lets you adapt it to the application . . . right on the job. You no longer need to predetermine circuit requirements before selecting a device. This means fast installation or quick adaptation when requirements change. A new system of adjustable cams on General Electric's lever limit switch makes this flexibility possible. A template—provided with every switch—guides changing the cams.

Lighter and more compact, General Electric limit switches are available for either two- or four-circuit operation . . . and, in a wide choice of enclosures.

Consider these key features of the new General Electric lever limit switch:

- **Readily-accessible contact blocks** are of unit construction, easy to wire.
- **Variety of levers** offers wide selection to meet your specific application.
- **Starwheel** may be set for either maintained or spring-return operation.

For the complete story, see your General Electric Apparatus Sales Engineer, or write Section 784-28, Schenectady, N. Y. for Bulletin GEA-7203. *Industry Control Dept., Salem, Virginia.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

Publication Service...

DECEMBER, 1960

You Can Obtain . . .

. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(1) Heat Treating Equipment

General Electric Co. has available a 4-page bulletin describing their fluidized bed heat treating equipment for annealing, normalizing, solutionizing, aging, hardening, quenching and isothermal transforming. The bulletin explains how the process works to permit up to 85 per cent reduction in heating time, intermediate quenching rates and excellent temperature uniformity throughout the work load. Charts show comparative heating and quenching rates for steel and a discussion of time savings with other metals including copper, aluminum and magnesium is included. Additional charts show models available, their ratings and dimensions. (Bulletin GED-4306)

(2) Shears for Strip and Bars

Specialized shears for strip and bars are covered in a 4-page bulletin published by Curry Air Shear Corp. Including air- and hydraulically-operated units, the bulletin presents data on mill-mounted shears, up - cut and down - cut shears, and bar shears.

(3) Pyrometer Bulletin

An automatic two-color pyrometer developed by Shaw Instrument Corp., is described in their 4-page brochure. The brochure gives complete descriptive details, general specifications on standard models, special features, typical applications and photographs of sensing head and control units. (Bulletin 10C60)

(4) Thermocouples and Pyrometer Accessories Guide

A buyers' guide and users' manual for thermocouples and pyrometer accessories is available from The Bristol Co. The bulletin contains a users' manual outlining possible applications of their pyrometer accessories, a buyers' guide which catalogs specifications of accessories and a third section giving thermocouple calibration data. (Bulletin P1238)

(5) Turboblower Bulletin

Available from North American Mfg. Co. is a bulletin describing their line of turboblowers. The bulletin covers the uses for these blowers in the areas of combustion, atomizing, agitating, blowing, cooling, drying, conveying, and exhausting. (Bulletin 300)

(6) Vacuum Melting Data Book

A technical data book on the consumable electrode method of vacuum melting super alloy steels has just been released by the Metallurgical Department of Midvale-Heppenstall Co. The booklet gives data on the melting procedure, the vacuum atmosphere of 5 to 50 microns, the size of the ingot and weight and what the process achieves. It then lists ten of the outstanding improvements possible with vacuum melting of super alloys, high strength alloys, roll and bearing steels, gives the data on how these steels can be supplied in billets, plates and forgings. Twelve pages devoted to various high temperature super alloys and high strength steels should be of interest to metallurgists and design engineers. This booklet provides data on products and applications throughout industry where critical parts must have a thoroughly reliable metal to stand up under high temperatures and severe shock loads. The data offered proves the maximum reliability and minimum rejects which are possible with consumable electrode vacuum melted steels.

(7) Refractory Fiber Felt

Johns-Manville Corp. has published a product information sheet describing a light-weight refractory fiber insulation known as Cerafelt. The sheet contains complete information on the material, and lists the available forms, recommended uses and advantages of the chemically stable material. Tabular data included are thermal conductivity at various densities and temperatures, and listings of standard densities and thicknesses. (IN-283A)

(8) Speed Reducers

"Parallel Shaft Speed Reducers" is a 36-page book available from Link-Belt Co. The book describes their completely redesigned and expanded line of "balanced design" parallel shaft reducers in 57 sizes, including 23 new sizes. Full information for selecting the correct drive for every application is also included. Sixteen pages of rating tables contain thermal and mechanical horsepower ratings for each input and output speed. Load classes are shown for almost 250 driven machines. Overhung loads, extended shafts and outboard bearings, dimensions and actual ratios are included in additional tables (Book 2719)

(9) Dust Control Equipment

Dust control equipment manufactured by American Air Filter Co. is described in a new composite product bulletin. Discussing the four main types of dust control

products—dry centrifugals, wet collectors, fabric collectors and electrostatic precipitators, the new bulletin explains and illustrates thirteen different AAF products, their capacities and their specific applications. Individual product bulletins for each piece of equipment described also are recommended for more detailed information. (Bulletin No. 271)

(10) Furnace Transformer

A 16-page descriptive booklet on electric furnace transformers has just been released by Pennsylvania Transformer Division, McGraw-Edison Co. The booklet includes a review of the basic design principles applied to transformers with high-current ratings, as well as construction details and principal accessories. Both internal and external features are illustrated by photographs and drawings. Materials and manufacturing processes are described (Bulletin No. PFT3M960)

(11) Roll Catalog

Barclay Machine, Inc. has published a catalog describing and illustrating the construction of rolls with stub shafts and through shafts, rolls with fabricated bodies and cast bodies, alloy rolls, stainless steel rolls, rubber covered rolls, plastic covered rolls and many other types including Lorig-Aligner (patented) self-centering rolls. Designs for use in all phases of ferrous and nonferrous strip handling and processing is also discussed. (Bulletin No. 601)

(12) Rotating Disks

Published by Dravo Corp. is a four-page bulletin describing their line of rotating disks for pelletizing or mixing such materials as ore fines, phosphates, ceramic clays, fly ash and oxides. The bulletin cites design features and advantages of the disks, which range in diameter from 39 in. to 16 ft-5 in. and lists typical capacities. Features of the disks that are stressed in the bulletin include, the classifying action of the disk in producing pellets of uniform size; the high output of the disk through continuous operation; the easy adjustability of plows, pan angle and rotating speed; the high quality of pellets produced; the infrequent necessity for binders; and the low over-all cost per ton of output. Dravo's plan for rental of the 39 in. disks for research and pilot plant studies also is noted. (Bulletin No. 247)

(13) Strapping Methods and Tools

A basic reference guide to strapping methods and tools is offered in a 40-page pocket-size booklet by Signode Steel Strapping Co. Descriptions of Signode's compression strapping and jib crane systems are included. Details also have been added on their recently-developed heavy-duty model feed wheel tensioner, the air-powered sealer, and new dispensers and strap cutters. A list of 12 strapping pointers is included to guide shippers to superior results at less cost. Charts of available materials and equipment are especially helpful to shippers. One chart lists 39 different sealers with their sizes, weights, the appropriate seals for each and a description of their action.

(14) Marking Machines

M. E. Cunningham Co. has issued an 8-page bulletin covering their slab, bloom, billet and ingot marking machines. Featured is a series of remotely-operated machines which can stamp 12 or more characters with a single marking head, or up to 26 characters in double-headed models. Various styles of marking machines are illustrated, and their advantages and uses are described.

(15) Automatic Crop Shear Control

A system for cropping mill slabs more precisely to result in production increases and scrap reductions is described in a bulletin published by General Electric Co. The bulletin describes the operation of the crop shear control, as well as how the crop shear increases productivity. A view of the control panel for the automatic crop shear is included. (Bulletin GEA-6949)

(16) Flexible Cushion Couplings

Dodge Manufacturing Corp. has published a bulletin describing their two new types of flexible cushion couplings, one for high speed, high torque applications and another for attachment to flywheels of internal combustion engines. Complete engineering data, photographs, dimension drawings and selection tables cover these new high speed and flywheel couplings as well as the original standard para-flex with its distinctive tire-shaped flexing member of cord and rubber construction. The new types feature a pan-shaped rubber flexing element, and are expected to multiply the potential applications for para-flex. (Bulletin 901)

(17) Open-Hearth Control Systems

The adaptation of automatic control systems to 12 open hearth furnaces is described in case history form in a 16-page bulletin issued by Hagan Chemicals & Controls, Inc. The bulletin graphically demonstrates how automatic controls can be successfully applied to older furnaces as part of an over-all modernization program, resulting in increased furnace capacity and faster materials handling facilities. Additionally, five steps which Hagan considers reasonable and economically sound in an attempt to achieve full automation of the open hearth process are listed in the bulletin. (Bulletin MSA-189)

(18) Buffing and Polishing Speed Calculator

Hanson - Van Winkle - Munning Co. has available a disk calculator for determining the surface speed of both buffing and polishing wheels. The calculator gives easy-to-use instructions on how to find the surface speed, in feet per min., of any wheel from 1 in. to 60 in. in diameter, turning at spindle speeds from 220 to 20,000 rpm.

(19) Welding Stainless Steels

A general reference guide on the subject of stainless steel welding has been published by The McKay Co. Detailed explanations are given on the various stainless steels in common use today. The practical procedures for their welding and types of electrodes and wires available for their use are covered in most part, in easy-to-follow question and answer form.

Questions are aimed directly at fundamental welding problems—and the answers point out the reasons for these problems and methods for arriving at solutions. In addition, the manual contains information on the specific effects of alloying elements in stainless steels and high strength heat resisting alloys. Also listed in a handy reference chart format, are the ASTM stainless steels with recommended electrodes in the welding of these steels.

(20) Fuse Panels and Switches

The Clark Controller Co. has available a product guide which gives installation and application data on a complete line of fuse panels, service entrance equipment, general-purpose switches, general-purpose toggle switches, safety switches, industrial switches and double-throw switches. A special engineering data section is included giving allowable current-carrying capacities of insulated copper conductors in amperes, the number of conductors in conduit or tubing and load and circuit information for residential electrical systems.

(21) Fireclay Refractories

A brochure which reviews the principal brands of their fireclay refractories produced at their West Coast plant in Ione, Calif., is available from Harbison-Walker Refractories Co. The brochure features specific refractory brands for medium-duty service, high-duty service and superduty service. It gives property descriptions; data on P.C.E. test, panel spalling test and load test results; and information on the mineral deposits, plants, warehouses and offices that serve the west coast states. Descriptions and photos of manufacturing operations are included along with information on available monolith-forming refractories and mortars.

(22) Heavy Duty Trucks

"Heavy Duty Trucks Facts and Factors" is the title of a booklet published by the Automatic Transportation Co. The booklet is designed to show the proper uses of industrial lift trucks and their versatility in a wide variety of industries. Steel handling is illustrated from the operator-led, Transporter to the Elbolift with both fork and ram attachments, to the Skylift Giant with capacities to 100,000 lb and special attachments to up-end coils up to 60,000 lb. Die handlers have been an Automatic specialty since 1927, with a choice of four loading methods; end, side, combination and tilting platforms for inclined presses. Each die handler is custom built for a specific job, capacities from 6000 to 200,000 lb.

(23) Shaft and Flange Mounted Drives

The Falk Corp. has published a bulletin discussing their shaft and flange mounted drives. The bulletin discusses the design and construction of these drives, how to use them properly, and how to select the best drive for your needs. Cross-section drawings illustrate the dimensions for these drives. NEMA motor information is noted, and photographs of typical installations are included. (Bulletin 7100)

(24) Overhead Materials Handling Booklet

A new issue of a booklet titled "Engineering and Application Data" has just been completed by the Cleveland Tramrail Division of The Cleveland Crane & Engineering Co. Various types of carriers, cranes, tractors, track switches, grabs, electrification are described. Detailed studies of track design, peening and stresses are given. A large number of photographs of a wide variety of Cleveland Tramrail installations are also featured. (Bulletin No. 2008-Q)

(25) Industrial Bucket Elevators

A 22-page booklet on industrial bucket elevators for the handling of bulk materials has been issued by Hewitt-Robins Inc. The booklet contains engineering data on various types of bucket elevators and recommends the grades of belting best suited for elevating materials of different weight, abrasiveness, temperature and other characteristics. One section deals with belt selection procedures based upon formulas developed over many years' experience in the design of elevators. Another section presents statistical tables on steel elevator buckets. There are also sections on trouble-shooting and belt splicing. (Bulletin No. 174)

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PITTSBURGH 22, PA.

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51	APPLETON ELECTRIC CO.	BULLETIN 505	Motor-driven reelites
52	ATLAS CAR & MFG. CO.	BULLETIN 1290	Dial scale
53	AUTOMATIC TRANSPORATATION CO.		Heavy duty trucks
54	BABCOCK & WILCOX CO.	CATALOG R-2-H	Insulating firebrick
55	BAILEY CO., WILLIAM M.	BULLETIN V-200	Goggle valves
56	BLISS CO. E. W.	BULLETIN NO. 60	Pulsation burner
57	BLISS CO., E. W.	BULLETIN 40-B	Rolling mills
58	BUSSMANN MFG. DIV., McGRAW-EDISON CO.	BULLETIN SCPS	Fuses
		BULLETIN FIS & HCS	Dual-element fuses and hi-cap fuses
59	CLARK CONTROLLER CO., THE	BULLETIN 9100	Crane controls
60	CLEVELAND TRAMRAIL DIV., CLEVELAND CRANE & ENGINEERING CO.	BOOKLET NO. 2008	Engineering and application data
61	CLEVELAND WORM & GEAR DIV., EATON MANUFACTURING CO.	BULLETIN 145	Speed reducers
62	CONE-DRIVE GEARS, DIV. OF MICHIGAN TOOL CO.	CATALOG NO. 58	Gearmotors
63	CUTLER-HAMMER INC.	PUB. LO-80-Y232	Unitized contactors
64	ELECTRO-ALLOYS DIV.		Heat-resistant alloys
65	EUCLID ELECTRIC & MFG. CO., THE	BULLETIN 3004	Heavy-duty resistors
66	FARRELL-CHEEK STEEL CO.	CATALOG 24	Alloy and carbon cast steel wheels
67	FLY ASH ARRESTOR CORP.	BULLETIN FD-11	Heavy duty fans
68	GENERAL ELECTRIC CO.	BULLETIN GEA-7203	Lever limit switches
		BULLETIN GEA-6706	Master switches
69	GENERAL ELECTRIC CO.	BULLETIN GEA-6701	Steel mill control panels
70	HAGAN CHEMICALS & CONTROLS, INC.		Blast furnace control systems
71	HOMESTEAD VALVE MANUFACTURING CO.	BOOK 39-3	Lever-sealed valves
72	I-T-E CIRCUIT BREAKER CO.	BULLETIN 4261-2b	Air circuit breakers
73	JOHNS-MANVILLE CORP.	BULLETIN IN-115A	Insulating fire brick
74	LINK-BELT CO.		Speed reducers
75	LINK-BELT CO.	BOOK 2716	Idlers
76	MIDVALE-HEPPENSTALL CO.		Roll hardness selector chart
77	PORTER, INC., H. K.		Rod and bar cutter catalog
78	POST-GLOVER ELECTRIC CO., THE	BULLETIN 410	Master switches
79	PRINGLE ELECTRICAL MANUFACTURING CO.		Industrial switches
80	SPRAYING SYSTEMS CO.	CATALOG 24	Spray nozzles
81	SQUARE D CO., EC&M DIV.	BULLETIN 6132	Magnetic control for d-c cranes
82	STEARNS MAGNETIC PRODUCTS	BULLETIN NO. 35-C-J	Lifting magnets
83	STEPHENS-ADAMSON MFG. CO., STANDARD PRODUCTS DIV.	BULLETIN 355	Carriers
84	WAGNER ELECTRIC CORP.	BULLETIN MU-224	Enclosed motors
85	WHEELABRATOR CORP.		Air filtering equipment
86	WHEELABRATOR CORP.	BULLETIN NO. 152-D	Descaling structural steel

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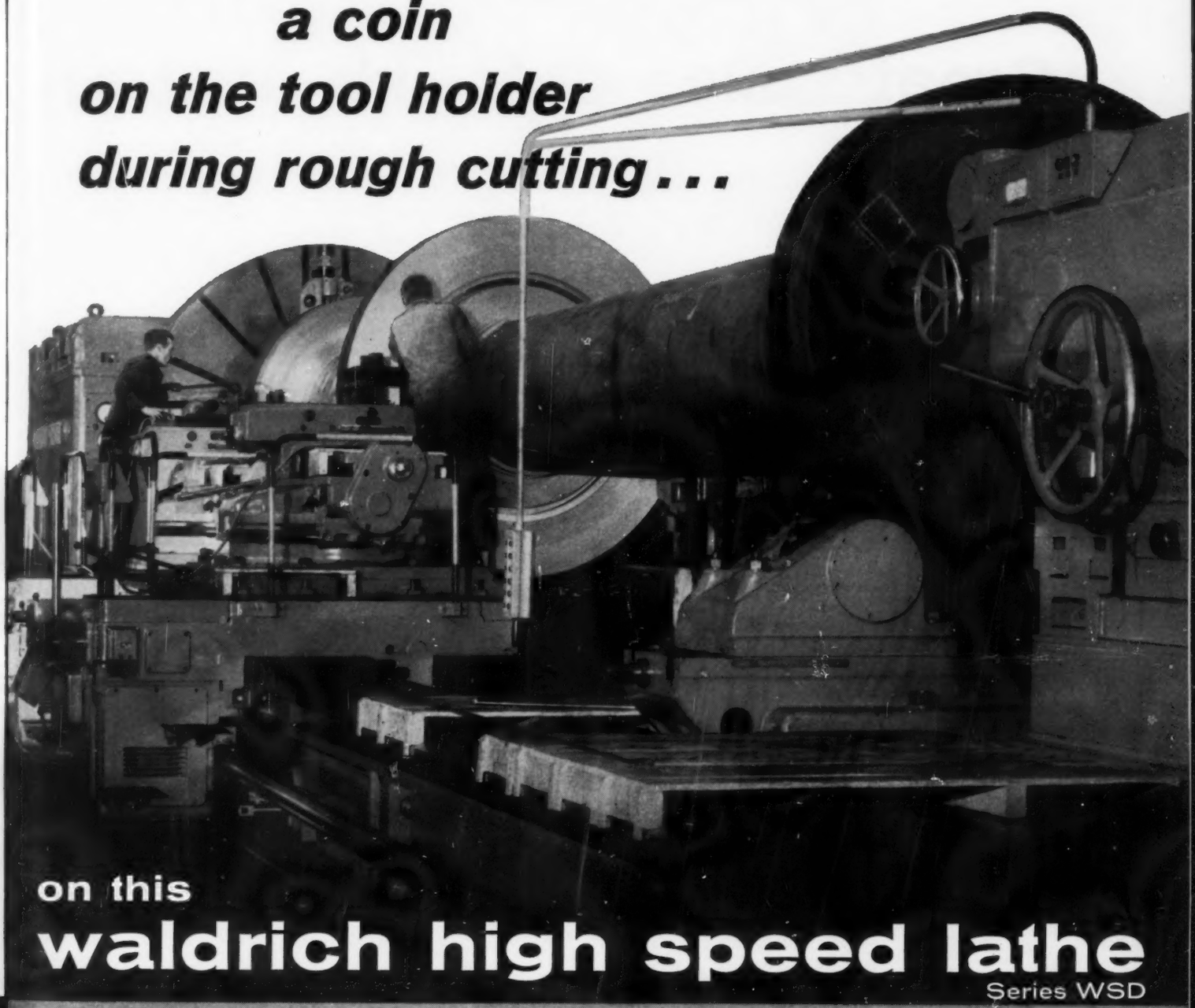
you can balance a coin on the tool holder during rough cutting...



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Great Lakes puts the heat on

A constant drive to hammer down production costs and deliver finished stock which customers will order a second time (or a twentieth) is apparent in the way the Great Lakes Steel Corporation "puts the heat on" their ingots, slabs, and coiled strip.

Fast heating shortens the time between ingot and strip. Uniform temperatures through the steel result in improved slabbing and rolling. Consistent annealing produces strip with the formability which reduces customers' costs. Great Lakes' selection of Surface equipment on existing facilities performing these heating jobs is justified by the fact that no other supplier has applied heat in so many ways—wherever metals are produced or worked. You are invited to make the most of this great fund of heating technology. Surface Combustion, 2404 Dorr Street, Toledo 1, Ohio.

Surface®

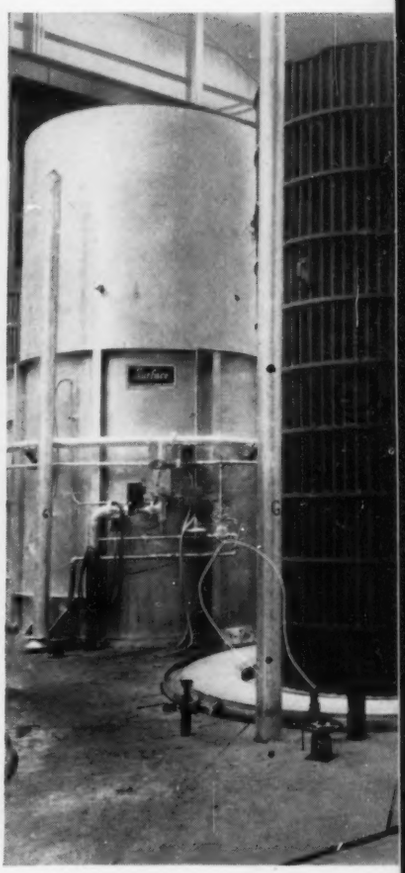
A division of Midland-Ross Corporation MR

Worldwide engineering and manufacturing facilities through associates

Forty Surface recuperative soaking pits, one-way, fired from the top.

Four Surface continuous recuperative slab heating furnaces, each with three zones.

in Australia • Belgium • France • Germany • Great Britain • Italy • Japan



Forty-four Surface multiple stand annealing furnaces with 108 bases; right: forty-six Surface single stand annealing furnaces with 116 bases.

At Kennecott's new refinery... **Twin Heroult Electric Furnaces designed**

Copper cathodes are charged into the 13,500 KVA Heroult 90-ton electric arc furnace, one of two at Kennecott Refining's new plant south of Baltimore. American Bridge also fabricated and erected the plant's structural framework.

to keep 16,500-ton per month copper melt on schedule

Kennecott Refining Corporation's electrolytic copper refinery near Baltimore is the country's newest—a showplace of efficiency. One reason: a pair of 90-ton Heroult electric arc furnaces, each rated at 40 tons per hour.

Of nose-tilt design to facilitate launder pouring, they discharge a steady stream of molten copper (2150°) which is used in the horizontal casting of wire bars and the continuous casting of billets. One Heroult is on normal capacity operation while the other is a spare for use during relining, when the pre-heat furnace is down, or when additional production is required.

Copper cathodes are preheated to about 1400°F and door charged into the Heroult arc furnace on a peel arm crane. The three-phase power input utilizing ultra-high speed mechanical positioning for three 20″ electrodes with high-speed sensitive regulators maintains a constant arc above the copper bath for uniform temperature casting.

The two 90-ton Heroult arc furnaces can be tilted 40° forward and 15° backward. They feature mechanically positioned masts and special water-cooled skew-back roof rings that introduce water flow at the critical roof juncture to prevent warpage and burn out.

Whatever your arc-melt problem there is a Heroult electric arc furnace design for you. We've made them from 3 tons to over 200 tons capacity, for both swing roof top charge or door charge operation. They can accommodate induction stirring equipment, and can be designed for duplexing arrangements. And every Heroult is designed for maintenance by your own crew.

American Bridge has a complete electric furnace service that includes new installation, furnace modernization and part replacement. We'll be happy to quote on your building needs, too. Call our nearest office.

USS and Heroult are registered trademarks

American Bridge
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United States Steel

USS

General Offices: 525 William Penn Place, Pittsburgh, Pa. Contracting Offices in New York, Philadelphia, Chicago, San Francisco, and other principal cities.
United States Steel Export Company, New York

This mark tells you a product is made of modern, dependable Steel.

Steel

TRABON®

CENTRALIZED LUBRICATING SYSTEMS

1/3 of a mile of brand-new, ultra modern steel mill at U. S. Steel's Duquesne Works is equipped with Trabon automatic centralized lubricating systems.

33 "original container" barrel pumps, each with its own automatic control and central warning system, serve the components of this tremendous new facility.

Included are the Mesta 45″ slabbing mill and shear, Birdsboro 36″ blooming mill and shear, United 21″ billet mill and traveling hot saws, Morgan flying shear, Linde Descarfer, Morgan, Alliance and Cleveland cranes, ingot buggy, tables and accessory equipment. It is indeed significant that the designers of this fine new mill selected Trabon.

In buying new or rehabilitating old machinery don't overlook the importance of a good lubricating system. When you specify Trabon — you get the best!

4522 Bearings at U. S. Steel's Duquesne Works expansion protected by TRABON

The new 36″ Birdsboro Blooming Mill is served by a Trabon heavy-duty Type MX System — *completely automatic—completely positive—and providing immediate central warning* at the control panel. Reset indicators in all valves quickly pinpoint trouble when central warning is given.

"*Centralized*" OIL AND GREASE SYSTEMS "*Meterflo*" CIRCULATING OIL SYSTEMS "*Meter-Mist*" OIL SYSTEMS

Trabon® **Trabon Engineering Corporation** 28785 Aurora Road • Solon 39, Ohio

Equipment News...

SUBMERSIBLE MOTOR

Δ A completely new line of submersible a-c motors has been introduced by Reliance Electric and Engineering Co. The pressure-proof motors, especially designed for close-coupling to centrifugal pumps operating in any depth of water, oil or liquid chemicals, are now available in sizes from ½ through 40 hp for operation from polyphase power sources, and from ¾ through 5 hp for single-phase connection.

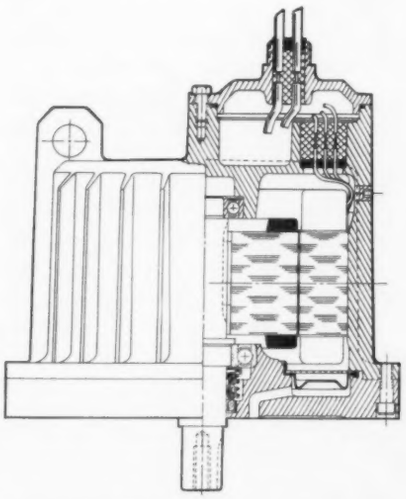
The new motors are rated at 55 C temperature rise for 30-min duty in 40 C air, and for continuous duty in 40 C liquids.

The heavy one-piece, ribbed housing of the new motors is leak-proof. Both the cast-iron motor frame and mounting base are impervious to corrosion.

Of exclusive "Liqui-Seal" construction, the motors are oil-filled to give total protection against bearing wear. They never need additional lubrication. The leak-proof construction seals in the motor oil as it seals out foreign contaminants. A specially designed neoprene diaphragm with a built-in O-ring completely encircles the motor base to disperse pressure differences over a large area. If internal and external pressures differ, due to heat or depth of immersion, the diaphragm flexes slightly to neutralize the pressure, thereby relieving pressure build-up around the O-ring and the positive shaft seal.

A reconnectable dual-voltage feature is available on single-phase units from ¾ through 2 hp, and on all polyphase motors. Motor leads are brought from the stator into an epoxy-sealed air chamber that is cast integrally in the top of the motor frame; the power leads are also brought into the chamber through an epoxy-sealed connector. The motor user may easily reconnect the leads for high or low voltage, as with standard a-c motors. A threaded extension is cast into the top of the frame to permit the installation of armored covering where required by local code.

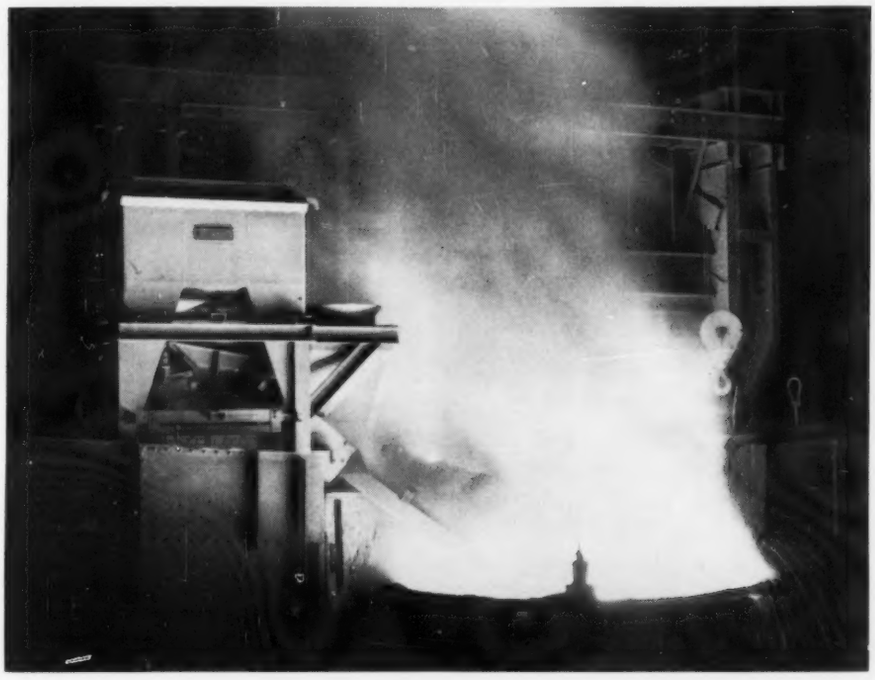
The motor base is precision-machined for true shaft concentricity. This provides easy, vibrationless close-coupling to the pump with no bothersome alinement problems. The impeller mounts directly on the motor shaft; the motor shaft serves as the pump shaft. The special universal mounting flange fits most standard pumps, and modifications can be made to meet special dimensional requirements. The pump-and-motor assembly can be lowered into position as a single, compact unit. Integrally cast rings at the top edge of the frame permit convenient, balanced handling.



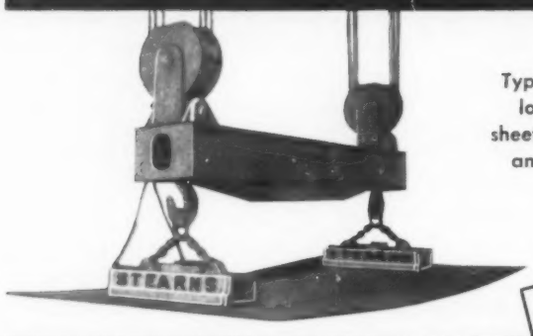
Cutaway view of new pressure-proof submersible a-c motor shows reconnectable dual-voltage lead in chamber at top right; neoprene diaphragm with built-in O-ring at bottom right; running face shaft seal at bottom center.

AUTOMATIC LADLE FEEDERS OPERATING AT FAIRLESS

This single bin automatic ladle additions feeder at the Fairless Works of U. S. Steel Corp., specially designed and built by Blaw-Knox Co., is one of two recently placed in operation in the open hearth shop. Both are weight type feeders—consisting of a hopper, electrical vibrating feeder, adjustable chute, electronic weighing system and a control panel—that automatically feed manganese and other alloy additions through a chute directly into the ladle. The feeders are designed to increase additive recovery by approximately 10 per cent, reduce inferior-analysis ingot rejections, and minimize slag runoff of additives. In addition, the units permit 12-speed feeding of predetermined amounts, and control blending rate of additives.

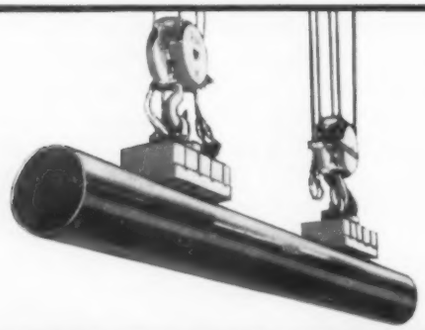


STEARNS lifting magnets make the tough jobs easy



Typical lifting arrangement for long, flexible, hard-to-handle sheet stock, using spreader bar and two rectangular magnets.

STEEL-MILL APPROVED



Two Stearns rectangular magnets work together providing fast, damage-free handling.

Dividends paid by magnetic handling go up when you specify STEARNS...the lifting magnets with real value built in.

Stearns' value means the highest performance and durability at the lowest cost. You can't buy better magnets at any price.

Check these advantage-features:

- **Cool Operating** — advanced coil design.
- **Superior Over-all Lifting Power** — extra-deep magnetic field.
- **Simplified Maintenance** — renewable bolted pole shoes.
- **Waterproof Construction** — all-welded magnet case.
- **Coil Life Safeguard** — automatically controlled oven-curing.
- **Protection Against Shorts, Leakage, Burnouts** — special class "H" insulation.

Standard circular or rectangular magnets are available in either bolted or all-welded styles, in a wide range of capacities and sizes:

Circular — 20" to 77" dia.

Rectangular — 9" x 24" to 26" x 80"

Whatever your steel-handling problem, Stearns engineers have the answer with built-in value.

Call in your local Stearns representative for a job-studied recommendation and price quotation, or write for Bulletin No. 35-C-J.

STEARNS MAGNETIC PRODUCTS

DIVISION OF INDIANA GENERAL CORPORATION • VALPARAISO, INDIANA

635 South 28th Street • Milwaukee 46, Wisconsin

Profit with Stearns — First with Ceramic Magnet Separators for Industry

Single-phase control panels are available to meet specific customers requirements. The basic control consists of necessary capacitors and a voltage relay. Locked rotor protection and overload protection may be added. An optional control feature is thermal protectors imbedded in the motor winding, so as to prevent failure if the motor is operated nonsubmerged for extended periods.

DUAL COMPRESSOR

△ A large dual compressor unit built specifically for providing both combustion air and cooling air in an iron ore pelletizing furnace installation was recently shipped from the Dearborn, Mich., plant of American-Standard Industrial Division.

The equipment consists basically of a pair of centrifugal compressors driven by a common double-end electric motor. The larger of the two blowers provides combustion air for furnace operation, while the smaller provides air for cooling pellets as they are discharged from the furnace. The combustion air compressor is an 885-hp unit having a rated capacity of 31,500 cfm at 6.0 psig discharge pressure and 3580 rpm; the cooling air blower is a 425-hp unit having a rated capacity of 28,100 cfm at 3.0 psig discharge pressure and 3580 rpm.

The special motor is a 1500-hp, 3600-rpm self-piped ventilated 4160 volt, 3-phase, 60-cycle squirrel cage induction double-shaft-extension type motor having forced-feed lubricated sleeve bearings and a Kingsbury thrust bearing.

RECORDER-CONTROLLER

△ The Bristol Co. is now offering a single-case time-program recorder-controller in its Series 500 instrument line. The incorporation of the recorder and the controller into a single unit affords a 50 per cent reduction in panel-space requirements.

The recorder chart and the program cam are independently driven. This makes it possible to record repetitions of the program on a single chart. The program time may be from 30 min to 30 days.

Various models of the instrument

NORTH AMERICAN engineered boiler burners

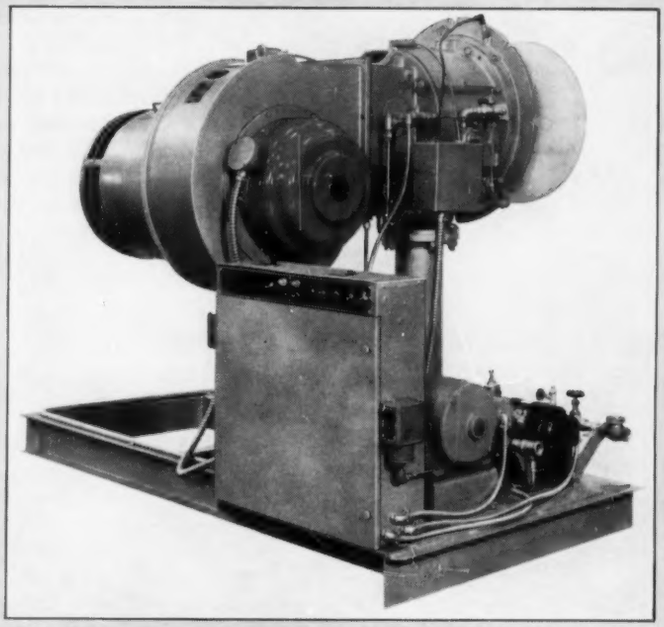
ARE BUILT TO GIVE YOU SERVICE today and tomorrow

Long-life North American packaged boiler burners have 43 years of combustion experience built into every unit. High quality construction assures low owning cost.

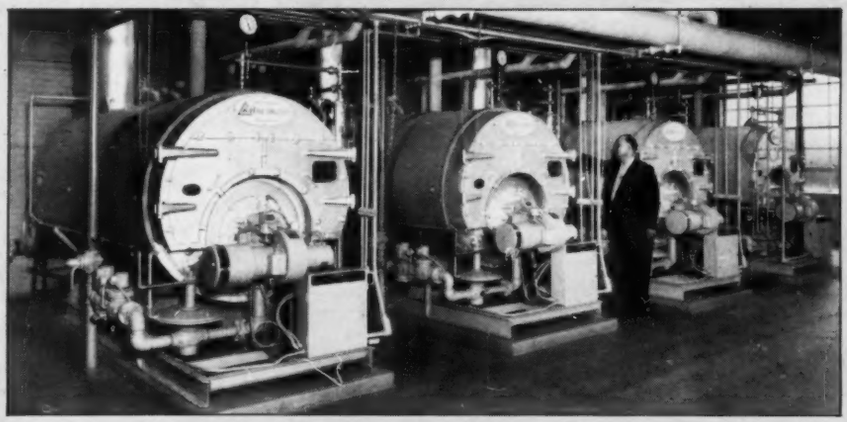
Designed to operate with gas, light or heavy oil, and for dual-fuel, these burners offer an input capacity range of 1,000,000 to 25,000,000 Btu/hr. Dual-fuel burners may be changed over from one fuel to the other by just turning a switch. There is no soot, fly ash or smoke with these fuels, including No. 5 and No. 6 oil installations.

Each unit has 100% combustion air supplied by a centrifugal fan. Low excess air requirements and high carbon dioxide percentages result in peak burner efficiency on new or old boilers. Burners may be used with negative and positive furnace pressures.

Burner units, which are hinged for ease of access, are available for firebox, H.R.T., Scotch Marine and packaged firetube boilers as well as longitudinal drum, cross-drum and "D" type water tube boilers.



Series 6121-18 Flame King Dual-Fuel Burner



Burners on Packaged Scotch Boilers at Mid-West Plant

Call your nearby North American engineer or write

NORTH AMERICAN for COMBUSTION and Hydraulic Controls

The North American Mfg. Co.
Cleveland 5, Ohio

At Burnside Terminal . . .

Fast, efficient ship-to-barge bulk cargo transfer effects big savings for plants on inland waterways

A deep-water port facility, Burnside Terminal, Burnside, La., is a two-way transportation center for ocean-going vessels and river barges. Heavy bulk materials such as iron ore, manganese, bauxite, phosphate rock, coal, raw sugar, etc. can be transferred from ship to barge, barge to ship, ship or barge to storage, or from storage to ship or barge. As a result, plants located on the Mississippi River System can benefit from lower material costs and inexpensive barge transportation.

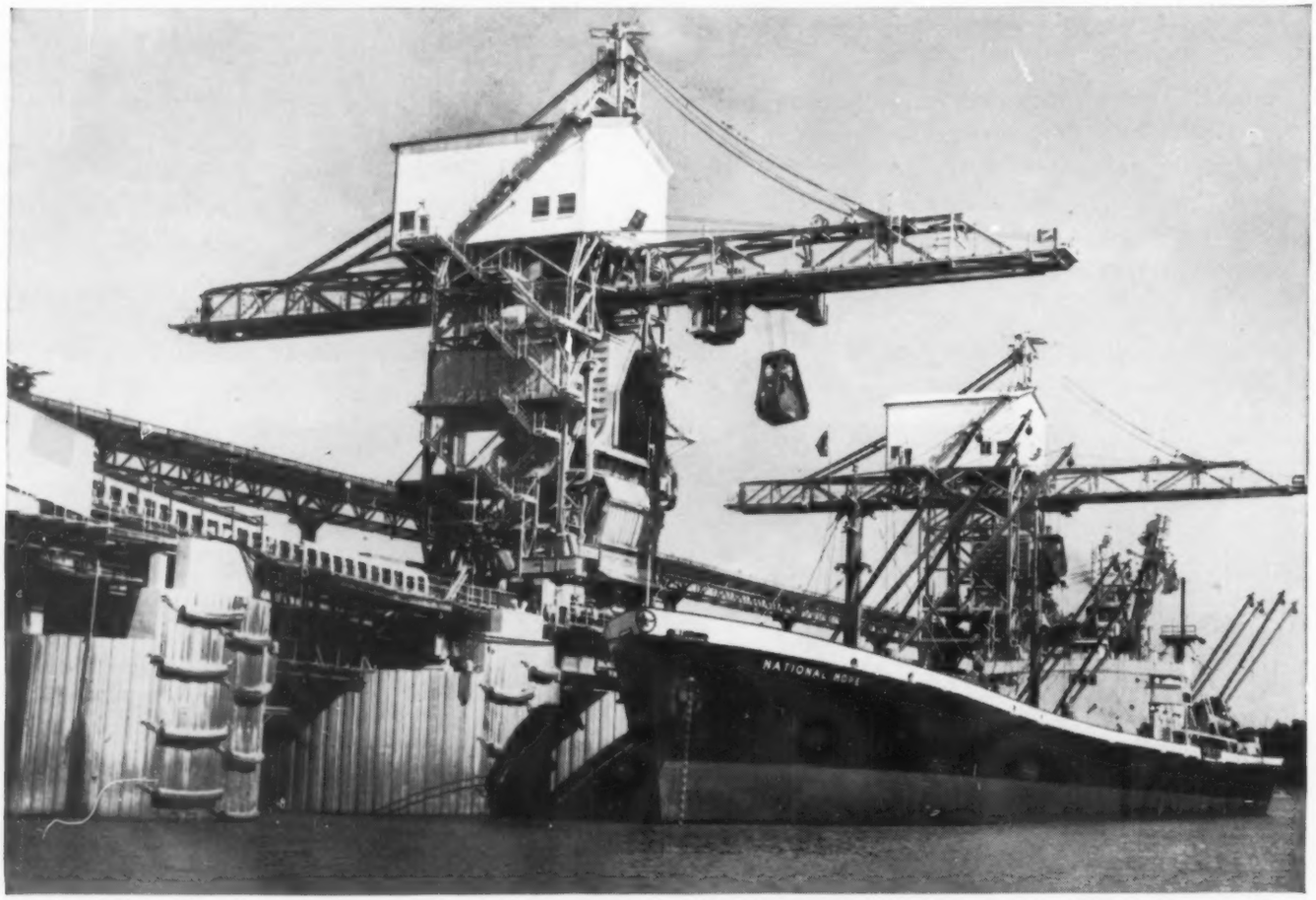
According to Captain H. O. Hall, assistant vice president of Ramsay, Scarlett & Co., Inc., operators of the terminal, the satisfactory performance of Dravo unloaders has been a major factor in providing this efficient, low-cost bulk cargo handling. Captain Hall puts it this way:

"Our Dravo unloaders help us substantially in assuring fast ship turn-around time.

"These cranes have lived up to the representations of the manufacturer. In fact, at times the free-digging performance in connection with bulk carriers has exceeded rated capacity.

"Because of the variety of bulk commodities handled here, speed in changing from one size of bucket to another is extremely important. With the new design of the Dravo unloader, the time required to change buckets generally is a matter of minutes."

This is typical of the benefits so many companies are getting with Dravo materials handling equipment. May we discuss your requirements with you? Write Dravo Corporation, Pittsburgh 25, Pennsylvania; or phone SPalding 1-1200.



Strategically located on the lower Mississippi River, Burnside Terminal provides an efficient facility for the transfer of bulk cargoes from ocean vessel and river barge. This is the most successful installation of this type now operating on the Mississippi.

DRAVO
CORPORATION

measure and control temperature, pressure (including absolute pressure), flow (mercury manometer or bellows-differential meter), liquid level and humidity.

Either pneumatic control or Bristol's Free-Vane electronic control is offered. Pneumatic control can be "on-off" or proportional or reset control. (An external manual-automatic station is available.

4-HIGH ROLLING MILL

Δ A new 4-high precision rolling mill, built by Steel Equipment Co. is designed for research laboratories, pilot plants or light production. The new mill, ideally suited for narrow-strip rolling, has an infinitely variable rolling speed, from 100 fpm to 1200 fpm. Anti-friction roller bearings and enclosed screwdown gearing permit accurate adjustment of the rolls. The totally enclosed construction protects against wear from dirt and grit; a one-shot central lubrication system assures long maintenance-free operation.

Screwdown action on the 4-high mill may be synchronized to keep rolls parallel or they may be set independently. Hardened steel roll guides are mounted adjustably at entry side of housings. Power screwdown is optional; dial-type screwdown indicators are furnished. The mill can also be equipped with automatic thickness-gaging equipment.

Work rolls are hollow bored for internal cooling. They may also be equipped for external pre-heating. Carbide inserts on the roll face, for extra heavy work or long runs can also be provided. Rolls are driven from a special two-high reduction unit through universal joints. Motor is flexible-coupling connected to high-speed shaft on reducer unit. The mill is equipped with a coolant reservoir and pump. The all-steel welded base of the mill is designed for maximum rigidity.

MEASURING SYSTEM

Δ A new, continuous, in-process specific gravity measuring system has been developed by Weighing and Controls, Inc. Designed for use with liquids, solutions, slurries, suspensions, emulsions, whips and creams, the new equipment operates

MANY FAST'S HAVE BEEN WORKING LONGER THAN YOU

It's a fact. There are plenty of cases where Fast's Couplings have been in service 20 to 40 years. And some of our more enthusiastic engineers say a Fast's should last forever if it's properly applied, installed and lubricated. Whatever opinion you accept, you can bet Fast's Couplings will give you the same smooth-running, low-maintenance, long-lived performance that makes them the choice of more equipment manufacturers than any other gear-type coupling.

For example, Fast's Coupling No. 1347, shipped in July, 1922, is still in service—and the customer is just ordering his first spare coupling 38 years later.

KOPPERS COMPANY, INC., 112 Scott Street, Baltimore 3, Md.

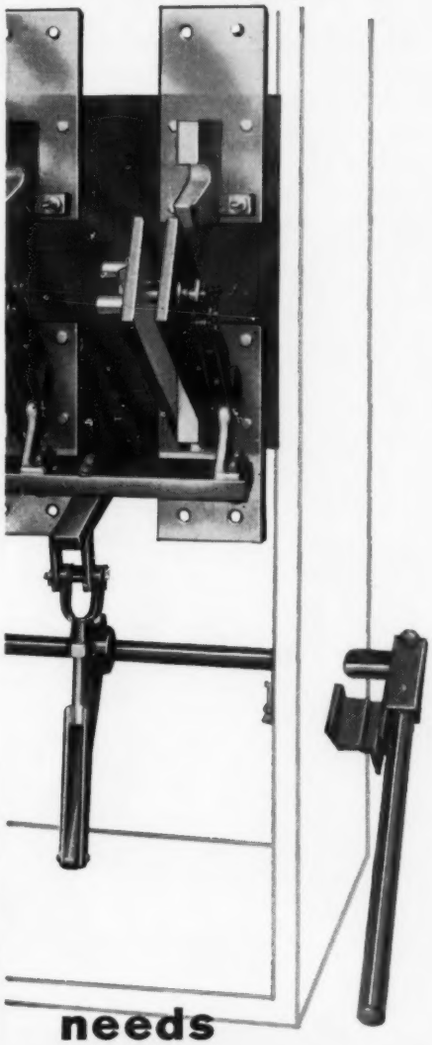
KOPPERS

FAST'S COUPLINGS

Engineered Products Sold with Service

RARELY

(IF EVER)



needs MAINTENANCE

Pringle disconnect switches for high-current equipment carry as much as 50,000 amperes, continuously, with no more of a heat rise than you would get from copper bus bars bolted together. These switch blades actually are bolted together. Under a constant pressure of 600 lbs./sq. inch. Without springs. Yet, they open easily after months (or years) of closed operation. Heat, fatigue, lack of movement won't affect the operating mechanism. Constant, periodic maintenance is unnecessary.

Less complex than most high-capacity disconnect devices. Less expensive too. Available in single- or multi-pole models, front or rear connected, live front or steel enclosed. With or without high-capacity fuses. For use on crane conductor rails, transformer secondaries, or AC and DC switchboards. Wherever high-current equipment must be isolated for periodic servicing.

Write for Industrial Switch Catalog

PRINGLE

ELECTRICAL MANUFACTURING CO.

1904 NORTH SIXTH STREET
PHILADELPHIA 22, PENNA.

without radioactive devices or complex mechanical transducers. Its output signals can be used for indication, recording, or control purposes.

In the system, a flexure-mounted pneumatic weight transmitter, coupled with a specially designed stainless steel tank, continuously weighs a constant volume of a slurry or liquid. Since the weight of the constant volume is directly proportional to the specific gravity of the material, readout is directly in specific gravity units.

Volume is kept constant by one of two methods. If the material contains air, a probe and an air vent valve maintain the liquid level by venting the top of the tank, permitting a closed pressurized system. Liquids which do not contain entrained or dissolved air can be measured in a simpler, open-top, overflow tank. In both tank designs, turbulence can be introduced by baffles so that contained materials remain in suspension. It is also practical to attach a motor mixer to the tank for agitation.

The system is highly accurate (better than 0.25 per cent overall), and gives excellent repeatability (1 part in 2000). Because of the rugged flexural mounting and pneumatic transmission, accuracy is long-lived; even under the adverse conditions, maintenance is negligible.

The pneumatic signal output gives wide flexibility and range; output pressure can be 3–15 psi or 5–40 psi, read on a scale calibrated to 0.1 per cent. The signal is essentially stepless, which permits exceptionally smooth control.

SUPERIOR
CARBON
BRICK
FOR
◀ Blast furnace linings
◀ Blast furnace run-out troughs
◀ Cupola linings
◀ Steel pickling tanks

Standard sizes and shapes • Tested performances
Competent technical service • Superior chemical and metallurgical characteristics • Graphite brick also available.

May we give you a quotation?

ELECTRODE GLC® DIVISION
GREAT LAKES CARBON CORPORATION
18 EAST 48TH STREET, NEW YORK 17, N.Y. • OFFICES IN PRINCIPAL CITIES

RUN-OUT TABLE MOTORS

△ New run-out table motors for steel mill application rated from ½ to 5 hp with base speed of 575 and 750 rpm are now available from the Westinghouse Electric Corp. These 240-volt units are suited for adjustable voltage operation.

The new motors feature permanent magnets which replace main field coils of standard design and require no field excitation power supply. This is a distinct advantage since the user need not purchase a d-c power supply generator for excitation. Furthermore, no field leads are required. Therefore, the cost of wiring and conduit usually necessary to supply the fields of standard run-out table motors is eliminated. Additional savings are realized because the field loss relay is no longer needed on the control panel.

These new units with permanent magnets reduce mill costs and maintain all the electrical and mechanical features of conventional run-out table motors.

UNIVERSAL JOINTS

△ A new line of universal joints for industrial applications up to 1500 rpm is available in both single and double joints in an extremely wide range of sizes.

Single joints provide smooth, sensitive operation through a full working angle of 40 deg and double joints through 80 deg. Rated at 0.35 to 190 hp at 100 rpm, they come in sizes from ⅜ in. to 4 in. and are available with square bore.

Case hardened and fine alloy steels are used to achieve light

CAR HEARTH FURNACES

FOR

HEAT TREATING
STRESS RELIEVING
ANNEALING
HOMOGENIZING
600°F TO 2500°F

DIRECT FIRED OR FORCED CONVECTION, OIL, GAS, ELECTRIC

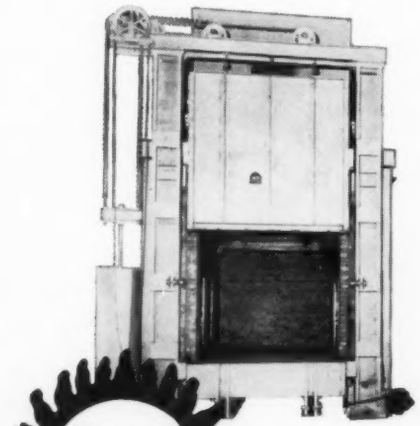
R-S CAR HEARTH FURNACES are batch type furnaces with movable hearth for ease of loading and unloading. They can be designed to your specifications as direct fired units for temperature range from 1000° to 2500°F. or as forced convection units from 600° to 1600°F.

R-S CAR HEARTH FURNACES can be built to utilize oil, gas or electricity, whichever is the most economical for your plant. Whatever the charge weight, length or width required R-S engineers can design and build the furnace to meet your requirements most efficiently.

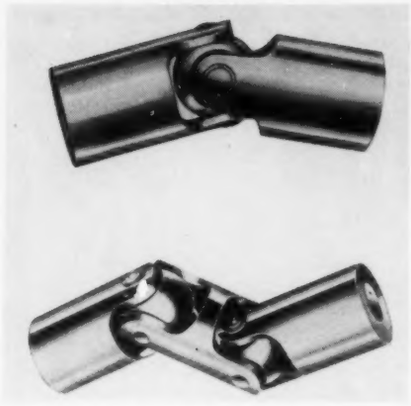
R-S CAR HEARTH FURNACES have proved themselves throughout the world. In foundries for heat treatment of steel and iron castings. In metal working plants for stress relief of weldments, annealing, normalizing, spherodizing and forging, or to heat for rolling, forming, or forging.

For full details on R-S Car Hearth Furnaces write to...

R-S FURNACE CO., INC.
NORTH WALES, PA.



R-S FURNACES



weight and exceptional durability. Some sizes are also available in various grades of stainless steel, and with bronze bushings surrounding the pins.

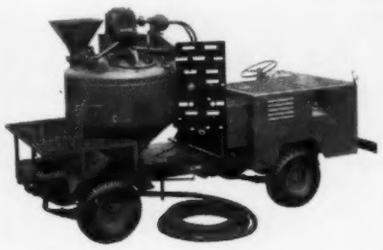
Precision manufacturing methods and machinery provide closest possible tolerances and exact alinement of blocks and bodies. Compact construction makes these joints ideal for close quarter applications. In addition, simplicity of design and absence of complicated parts contribute to long life and negligible maintenance.

REFRACTORY GUN

△ Basic Incorporated has announced the introduction of a new wet-mix refractory gun, BRI Model W-K.

Used primarily for the emplacement of refractory materials onto open hearth furnace skewbacks, backwalls, front walls, port skews and uptakes, this new gun makes possible easier, faster, less expensive repairs to hot open hearth and electric furnaces.

The gun enables operators to emplace thick furnace patches at



any time during the heat cycle without shutting off fuel and incurring lost production time. Users of the new gun may expect virtual elimination of skewback and backwall maintenance at rebuild time. Greatly increased roof life can be anticipated as a result of the additional support of a well-maintained

VALUED FOR

Depend-ability

TM alloy slings

TM Alloy Slings have a reputation for dependability . . . brute strength and low overall costs. Factory-made. Certificate of Test furnished. Bulletin 14A contains all data. Call your distributor, steel warehouse, hardware wholesaler or write—

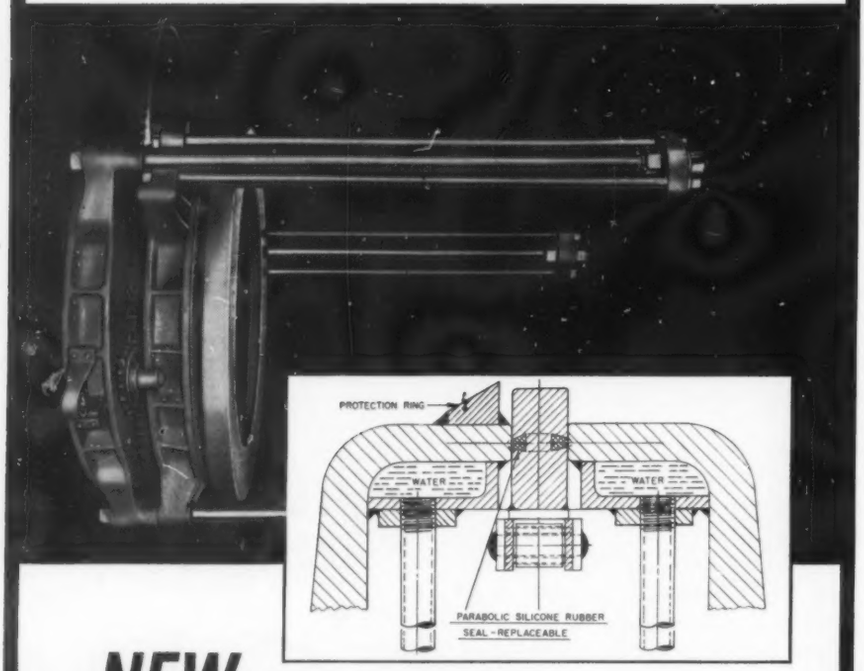
S. G. TAYLOR CHAIN CO., Inc.
Plants: Hammond, Indiana
3505 Smallman St., Pittsburgh, Pa.

Prompt repairs on alloy slings in both plants.

Taylor Made CHAIN SINCE 1873

World's First

Water-Cooled, Silicone Rubber-Seated GOGGLE VALVE



NEW... GAS-TIGHT Service for High Pressure Furnaces

Designed for use between dustcatcher and washer, this valve features parabolic silicone rubber seats in the goggle plate, and water cooled flanges. Design provides a tighter, more gas-proof seal than is possible with metal-to-metal seals. *Write for Bulletin V-200.*

BAILEY *Thermal Expansion* GOGGLE VALVES

WILLIAM M. BAILEY COMPANY • 1221 BANKSVILLE ROAD • PITTSBURGH 16, PA.

backwall and skewback.

Mounted on a sturdy truck chassis, the new unit mixes and agitates refractory material in a hopper pressurized to 70 lb psi. Additionally, the truck provides power for both mixing the material and easy maneuvering of the gun to any position on the furnace floor without interfering with normal furnace operation.

Connected to plant water and air supplies, the gun shoots refractory materials up to 4 mesh in size with water additions ranging from 15 per cent upward, depending upon furnace temperatures. Water is added through a direct reading meter for accurate proportioning. Handling up to 1900 lb of mixed material at one time, the gun is operated by a two-man team; one handling the control valves; the other at the nozzle of a 1 in. shooting pipe. Rates of delivery can be varied up to 400 or 500 lb of material per minute.

In addition to normal furnace maintenance, the gun is also used for shooting holes in the back banks. Large holes in the slag line can be filled with speed and ease.

The gun is unique in that it can shoot a coarsely sized refractory into hot furnaces. The hopper is designed to accommodate both wet and dry refractories. By changing two connections the model can be shot as a nozzle-mix gun for operations requiring low and varying amounts of water, such as many electric furnace repairs. In this case, water is added to the refractory as it passes through the shooting nozzle.

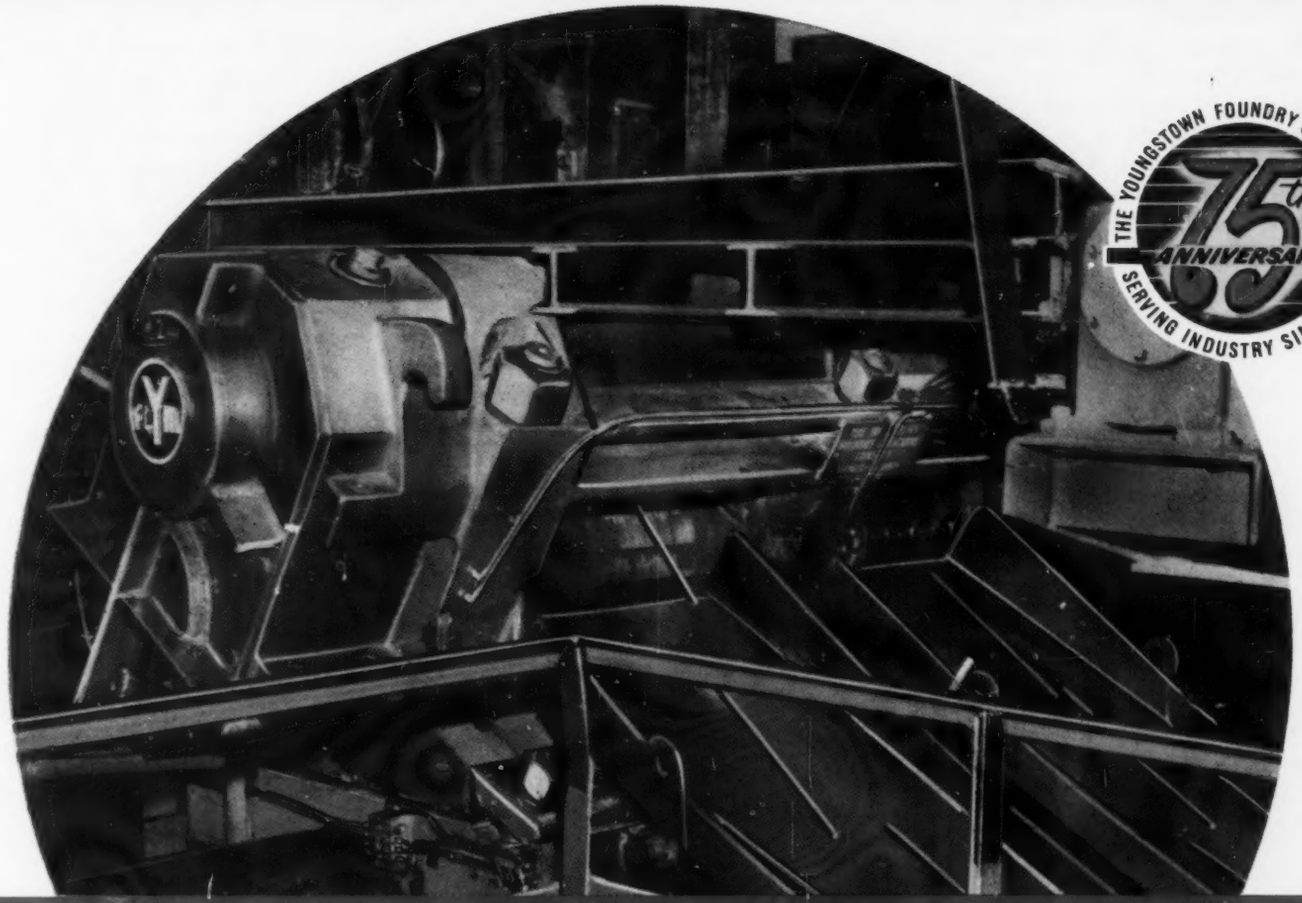
Mobile, easy to operate, safe and rugged the gun requires a minimum of maintenance.

PUSHBUTTON

△ Cutler-Hammer has introduced an oil tight, illuminated pushbutton that combines the functions of a pushbutton and an indicating light in a single unit.

The illuminated pushbutton incorporates a color-coded, molded type transformer that is designed to be immune to voltage surge lamp damage.

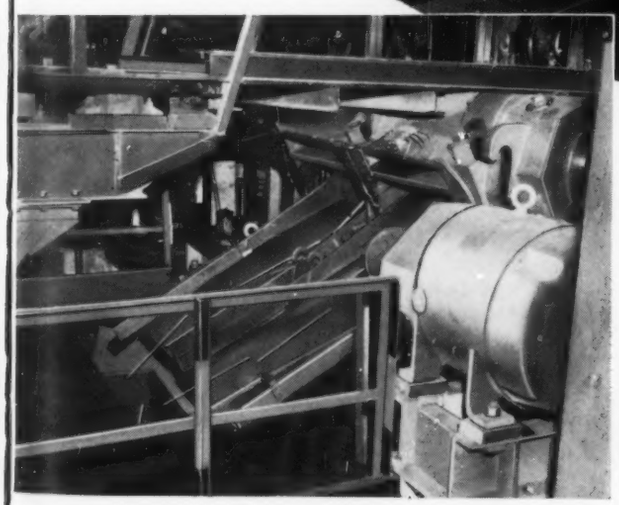
An outstanding feature of the device is the fact that it can operate with multiple contact blocks with any combination of N.O. or N.C. contacts.



THE YOUNGSTOWN FOUNDRY & MACHINE CO. 75th ANNIVERSARY SERVING INDUSTRY SINCE 1886

"YOUNGSTOWN"

Rotary-Type PLATE SCRAP CHOPPER



Scrap sliding down exit chutes from rotary chopper onto conveyor which discharges into scrap box or railroad car.

Unique Reciprocating Design prolongs knife life...saves downtime

Here's the scrap chopper designed for ruggedness and efficiency... built by "Youngstown" for a leading steel company. It handles side trimmer scrap 3" wide, ⅛" to ½" thick and cuts to 14⅛" constant length at speeds of 45 to 180 fpm. This rotary type scrap chopper is also built for ¾" and 1" thick plate; it can be built integrally with a side trimmer for a new line or application.

The arbor and housing assembly is designed as a separate unit mounted on a motor driven reciprocating carriage. Each arbor is equipped with four 30" long knives, with the knives so spaced that only one side is cutting at a time. This feature, along with the reciprocating action, insures longer time between knife dressings.

This design provides a spare housing and arbor assembly so that knives can be changed or adjusted on the floor, saving valuable mill time while changing knives. Housing and arbor assembly change time is held to a minimum through fast disconnect from drive and reciprocating carriage. Write for complete information.

The Youngstown Foundry & Machine Co. Youngstown 1, Ohio

Other features include base and one-hole mounting, functionally styled plastic lenses in red, blue, amber, green, clear or white and a positive mechanical "feel."

The oil tight, illuminated push-button is available for 110, 220, 380, 440 and 550 volt applications.

CONTROL CABLE

△ The Okonite Co., subsidiary of Kennecott Copper Corp., has introduced a new small-diameter plastic control cable, Okonite P-30. A low cost general purpose control cable for utilities and industries, it is suitable for all types of installations —conduit, aerial, duct, tray, direct burial, in wet or dry locations.

The cable is over 30 per cent smaller and lighter than conventional rubber cable, yet it offers advantages similar to those normally associated with these cables. Multi-wall construction offers three-fold electrical protection since the basic conductor insulation, its protective covering and the overall jacket are all high quality dielectrics. The double wall of mechanical protection against the chemical attacks of oils, acids, alkalies and other materials, plus the tough physical and flame-resistance qualities of the outer jacket makes the cable ideal for use under rigorous operating conditions.

Reduction in size and weight is in line with today's trend to lighter,

more compact control cable designs for use where space is limited. There's greater ease in installation, too. Recommended particularly for d-c circuits in wet locations and for temperature ranges to 75 C, Okonite P-30 small-diameter control cable fits all requirements for economical, high-quality control installations.

REFRACTORY CEMENT

△ A new ready mixed, air setting refractory cement has been marketed by Johns-Manville Corp. Called Super Blakite, it was developed as a refractory coating for use over vertical boiler tubes.

Super Blakite is furnished in a stiff consistency for use as a trowel coating and is directly applied from the container. Because of its workability, high strength and good adhesion, it can be applied to smooth metal plates that are directly overhead. On applications of 1-in. thickness, it will not crack or dry when subjected to heating.

In addition to boiler uses, the cement can be used for laying fire clay brick and super duty brick when thinned with water to the proper working consistency. It can also be used for shallow, cold patching of refractory masonry. The material can also be utilized for coating the inside surfaces of duct linings subjected to flue dust abrasion.

Super Blakite is available in 50, 100, and 220 pound containers.

D-C CONTACTORS

△ Cutler-Hammer has developed a new line of unitized d-c contactors for use on heavy-duty mill con-

IT'S OUR FAULT!

We thought everyone knew the advantages of using the Atlas Dial Scale with enclosed mercury switches to automatically control coke weighing at the skip hoist.

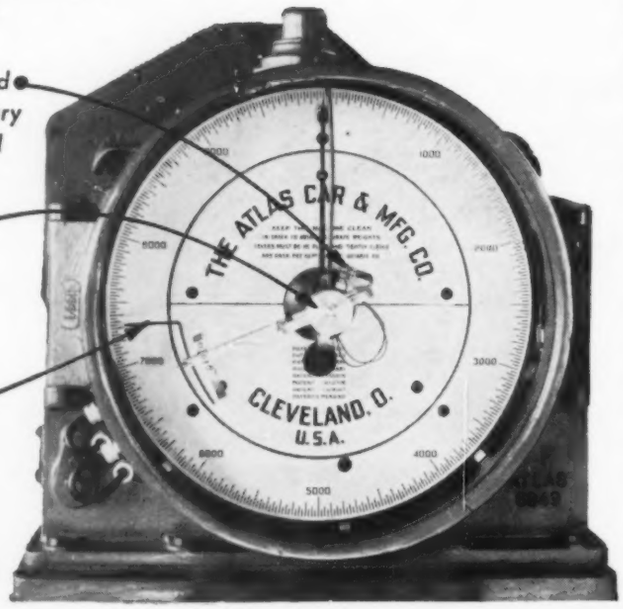
The important and outstanding advantage is that the tripping point can be set instantly by anyone from a knob outside the dial. No skilled technician is necessary.

Contacts, zero and adjustable trip, can be either make or break, as desired.

Enclosed dust and waterproof mercury switches to control weighing.

Outside knob adjustment on dial face to set tripping point.

Dribble compensating indicator on trip arm.

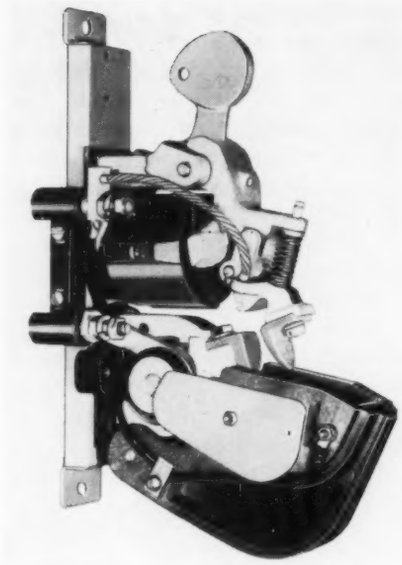


Ask for Bulletin 1290 for details.

Also for use with Electronic Scales.

ATLAS CAR & MFG. CO.

1100 IVANHOE ROAD / CLEVELAND 10, OHIO



trollers and integrated control systems, plus a wide variety of other industrial applications.

These newly designed contactors are available in ratings of 100 and 150 amp. The firm already has 25 and 50 amp unitized devices. Contactors with ratings of 300 and 600 amp will complete the line.

Unique unitized design allows greater mounting-wiring flexibility. Each contactor is fixed on an insulated steel base which can be mounted directly on either steel or slate supporting panels, thus providing either front wiring or rear-of-panel main wiring. A third wiring variation can be obtained by mounting the contactor on a spacer—this allows control wiring to be channeled "under the contactor" on panels where wiring space is at a premium.

Improved molded arc chutes and magnetic blowout structures insure longer operating life for the new line by quickly absorbing and dissipating heat caused by the arcing.

Another feature of the line is "piggy-back" interlock assemblies. Predrilled mounting holes are on the unit base to accommodate interlock mounting brackets. Maintenance personnel merely attach the interlock to a bracket and bolt the assembly in the desired operating position on the contactor.

Book Reviews

"Elementary Structural Analysis" (second edition) by Charles Norris and John Benson Wilbur has

For continuous thru-put and inventory data—W-C CONVEYOR-SCALE SYSTEMS

With a W-C Conveyor-Scale System incorporated in your process scheme, you can have up-to-minute thru-put data at any point from incoming transfer to inventory stock-pile. This data, expressed in terms of weight per unit of time, can be totalized for inventory records, process programming, or other manufacturing and accounting functions.

W-C Conveyor-Scale Systems can be supplied for flat or trough-type belts, fixed or variable speed, in capacities from 20 to 1000 tons per hour for new or existing conveyor installations. Each is a job engineered system employing standard, unitized components. As a result, you get a "custom" system at an "off-the-shelf" cost.

Typical applications include: Conveying and totalizing weight of ore from boat unloading stations; controlling feed and blending of materials to furnace.

Write for new Bulletin 60

W & C **WEIGHING & CONTROLS, INC.**
Div. of CompuDyne Corp.

E. County Line Road • Hatboro 16, Pa.

More equipment manufacturers choose Fast's Couplings than any other gear-type coupling

Leaving other claims aside, the thing that counts in couplings is customer confidence—and industrial equipment manufacturers have made Fast's their overwhelming choice. The Fast's line is more diversified, too—in a complete range of sizes and types for shafts, from ½" to 32" and larger.

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been published recently by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 38, N. Y. The book contains 651 pages, 6 x 9 in., is cloth bound, and sells for $10.50. In this second edition the general format, philosophy and method of presentation of the first edition have been retained. The entire text, however, has been reworked and improved. Major changes have been introduced to comply with structural engineering developments and achievements. More efficient utilization of steel, concrete, and wood, as well as the expanded use of structural aluminum, are amplified, and these advancements permit the designer to utilize new and more efficient structural forms. Several chapters have been completely rewritten or amplified, while others have been integrated with allied topics. One new chapter discusses certain aspects of plastic behavior of structures. Line drawings, tables, equations, etc., substantiate the text.

"Unfired Pressure Vessels," by Robert Chuse (fourth edition) has been published recently by F. W. Dodge Corp., 119 West 40th Street, New York 18, N. Y. The book contains 154 pages, 6 x 9 in., is cloth bound, and sells for $8.75. This fourth edition has been enlarged, revised, and updated to include current requirements of Section VIII Rules for Construction of Unfired Pressure Vessels and Section IX on Welding Qualifications of the ASME Boiler and Pressure Vessel Code; it simplifies ASME code requirements for pressure vessels. The work is presented in an easy-to-understand manner and contains useful information to evaluate ASME code design. The book includes 66 tables, charts and diagrams, enabling quick, accurate calculations for designing, ordering, fabricating, inspecting and repairing unfired pressure vessels.

"Tinplate Testing—Chemical and Physical Methods," by W. E. Hoare and S. C. Britton, has been published recently by the Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex, England. The book contains 55 pages, 6 x 9¾ in., is bound in heavy paper, and copies are available free of charge from the Institute. This handbook deals with the superficial layers of the tinplate, so does not describe mechanical testing procedures. However, discussed are quality test methods for thickness and continuity of the tin coating, the determination of the oxide and oil films are compared as well as discussed; also performance tests for rust resistance, staining, lacquerability, solderability and corrosion. This handbook is also available from other offices of the Tin Research Institute located in Brussels, Belgium; Montreal 2, Canada; Paris 8, France; Dusseldorf 22a, Germany; The Hague, Holland; Milan, Italy; Stockholm 16, Sweden; and 492 West Sixth Avenue, Columbus, Ohio.

"Industrial Electric Furnaces and Appliances" (second edition) by V. Paschkis and John Persson has been published recently by Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y. The book contains 607 pages, 6 x 9 in., is cloth bound, and sells for $24.00. In this second edition, revised and enlarged, the two volumes of the first edition are consolidated into one, enabling a desirable rearrangement of the material. The thermal problems separated into two volumes of the first edition are now

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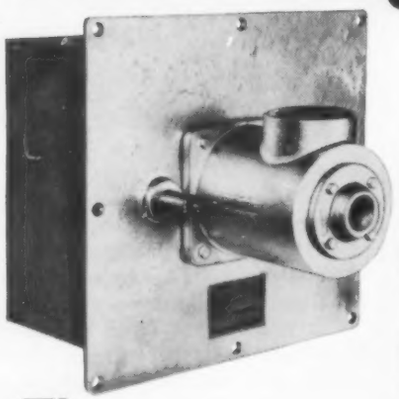

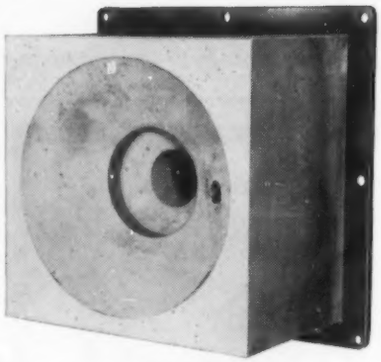

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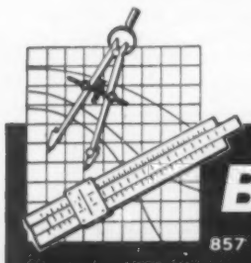

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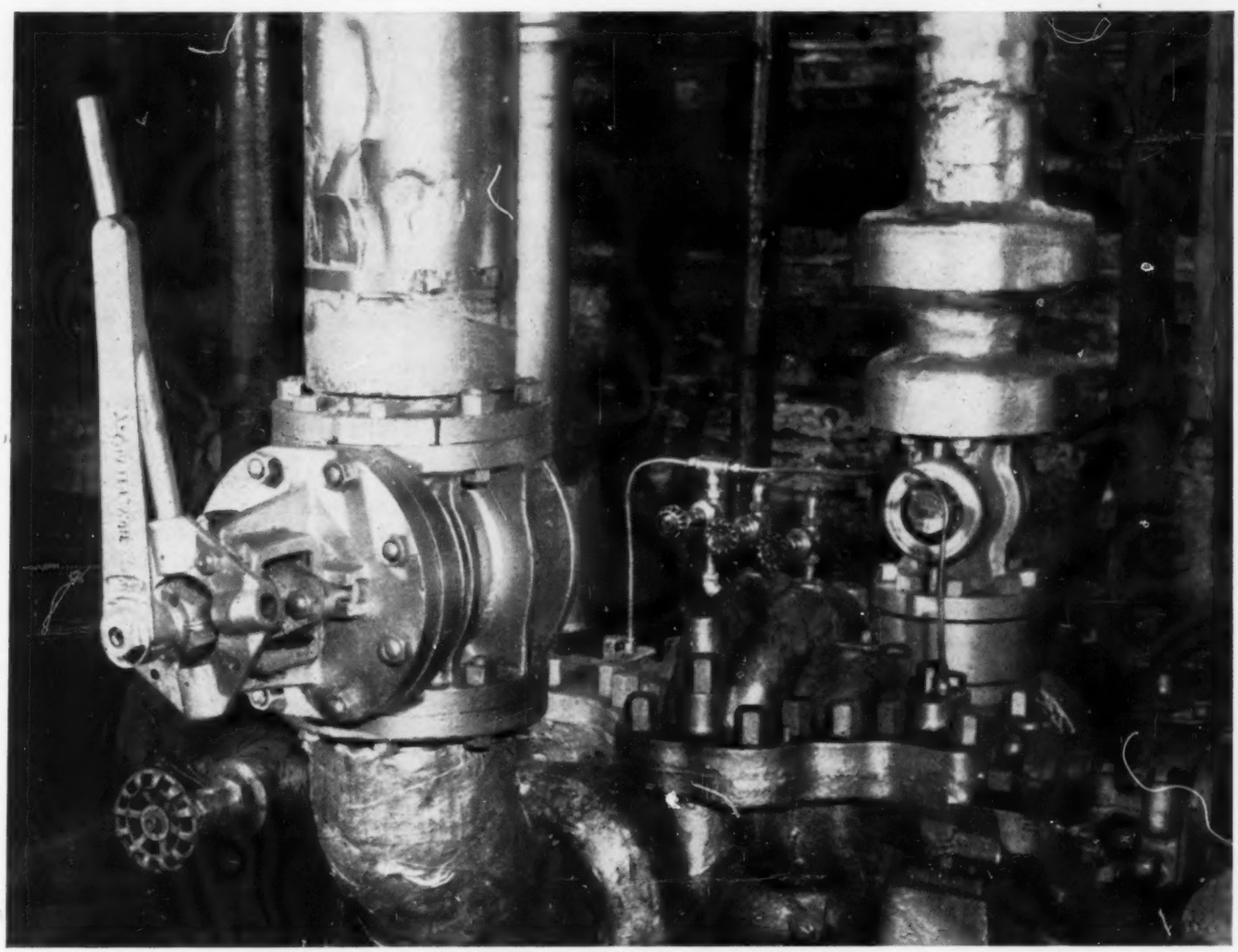

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"**Cost Reduction and Profit Improvement**" has been published recently by the Machinery and Allied Products Institute/Council for Technological Advancement, 1200 Eighteenth St., N. W., Washington 6, D. C. The booklet contains 67 pages, 6 x 9 in., is bound in heavy paper, and sells for $2.00, available from the Institute. (Quantity discounts are available: 1–9 copies, $1.50 each; 10 to 39 copies, $1.25 each; 40 to 89 copies, $1.00 each; 90 to 149, 85¢ each; 150 and over, 75¢ each plus postage and shipping costs.) This booklet presents the informal and practical observations of 14 capital goods executives covering manufacturing, marketing, purchasing and finance. The views in the pamphlet emphasize the responsibility of top management and at the same time underline the need for a full team effort involving all parts of the organization.

"**Erecting Structural Steel,**" by Samuel P. Oppenheimer has been published recently by the McGraw-Hill Book Co., 327 E. 41st Street, New York 36, N. Y. The book contains 272 pages, 6 x 9 in., is cloth bound, and sells for $9.50. Modern methods for erecting a wide variety of steel structures, ranging in coverage from basic planning of structures to the installation of roof and beams, are presented in this book. It includes types, names, descriptions and uses of equipment involved in structural erection. Many other factors such as tools, scaffolding, work methods, erection procedures, are discussed, and the business aspects of testing, selling and managing are covered. The book gives information on recent developments in such areas as reinforced concrete structures, the structural steel frame and miscellaneous iron, including stairs, fire-escapes and structural door frames. Facts are provided on slewing and automotive cranes, welding guns, high-strength bolts and other types of modern equipment. Sample work-control and office forms, examples of computations, and numerous illustrations expand and clarify the text.

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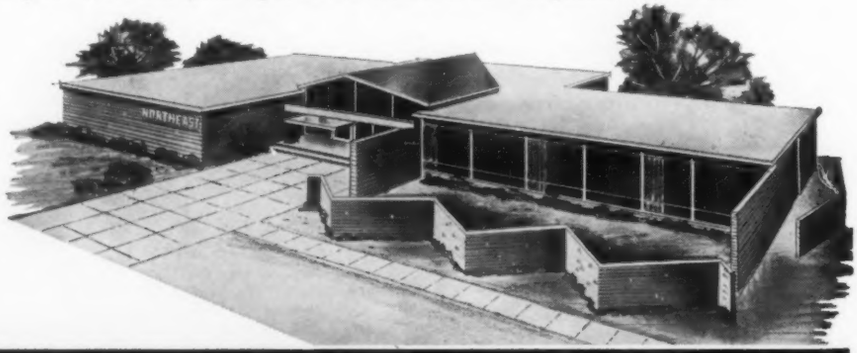

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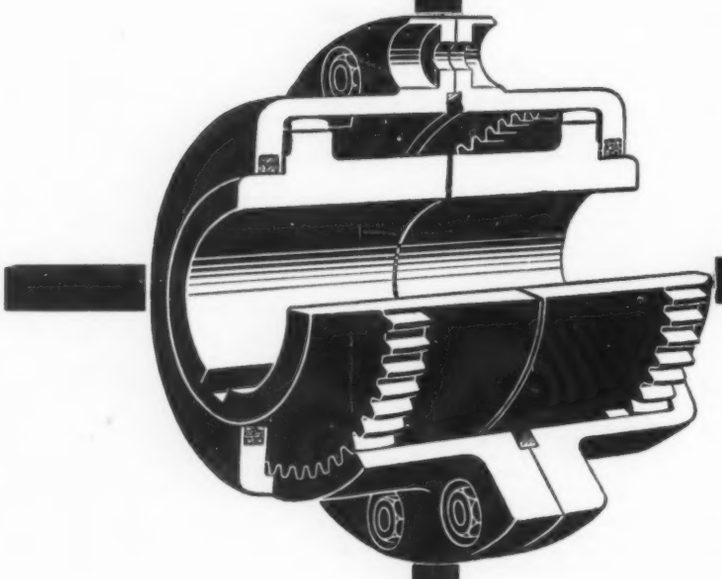

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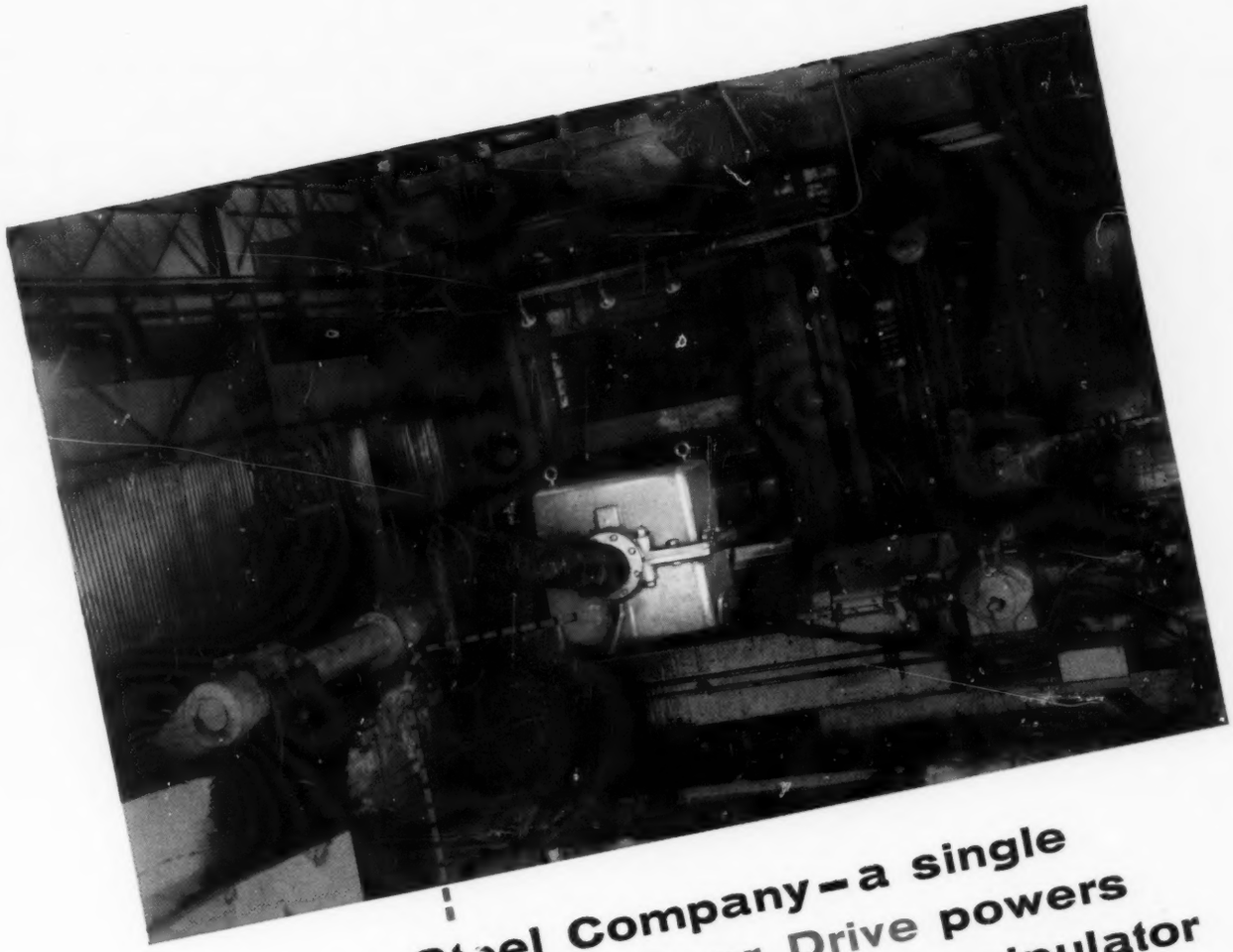

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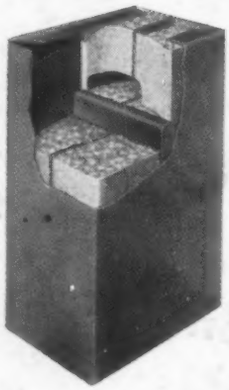
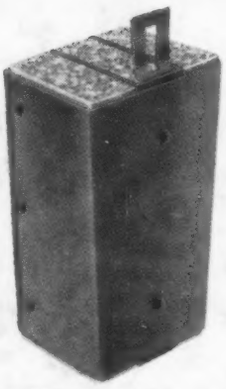
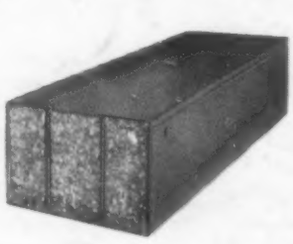
Metalkase brick are furnished in various sizes and shapes. They are made in both chemically-bonded and hard-fired basic refractories of various compositions which are used with particular benefit in suspended roofs and in walls in steel and nonferrous metallurgical furnaces.



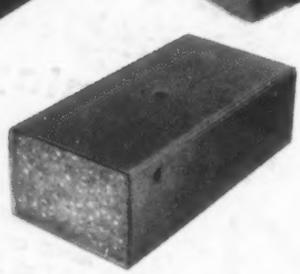
METALKASE SUSPENDED ROOF ASSEMBLY. This composite basic brick roof shape is made with both hard-fired and chemically-bonded basic brick with interior plates—ready for use as received. Suspending member is inserted, turned through 90 degrees becoming automatically locked. Important benefits result from the prefired refractory in some applications.



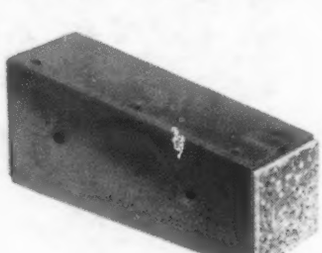
TABKASE MAGNEX OHR XXP brick externally and internally plated have a stainless steel tab welded inside the insert which is flat with the end as shipped. At the place of use, they are bent to the upright position and hung back-to-back in place. This innovation in design contributes materially to long service and notable economy in parts of open hearth steel furnaces.



METALKASE XXP are chemically-bonded basic brick formed under high pressure with two internal plates. They are available in various compositions and are furnished in standard sizes and suspended arch and other shapes. METALKASE MAGNEX OHR most widely used in open hearth steel furnace roofs continues establishing unit roof life records. The high purity magnesia produced by Harbison-Walker from Michigan brines and stabilized as dense periclase is an important constituent which measurably enhances the desirable properties of this refractory.



METALKASE BRICK (externally plated), both hard-burned and chemically-bonded in various compositions, are made with either three or four-sided steel casings. Used for many parts of open hearth steel furnaces, for sidewalls and door jambs of electric furnaces and in other applications requiring high spalling resistance in basic composition, they very satisfactorily withstand extremely severe conditions.



EXKASE basic roof brick are made with patented four-sided welded cases provided with a bendable projection which insures proper expansion allowance. This automatic means of accurate expansion allowance avoids the need of burn-out spacers. With EXKASE, furnished in various key sizes for roofs, installation is simpler and costs less.

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